ANTISEPSIS AND ANTISEPTICS

BUCHANAN

SOME OF THE WORLD'S GREATEST SURGEONS AND BACTERIOLOGISTS.

Antisepsis and Antiseptics.

— BY —

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WITH AN

INTRODUCTION

— BY —

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PROF. AUGUSTUS CHARLES BERNAYS.

To write an introduction to a book like the one before us, is a pleasure indeed. The material gathered for this work by the Author and now presented to the busy Doctor in convenient form will be a most welcome aid in practice. It gives the views of the best living scientific biologists who have experimented in the field of pathogenic bacteriology. It also has compiled the practical rules followed by many of the best surgeons in the world in their daily work. These rules and recommendations are based on the results obtained in thousands of surgical cases.

An apology for a practical manual of Antiseptic technique at

the present time is unnecessary.
Every surgeon must practice his art
with all the safeguards afforded by
Antiseptics and ~~Aseptics~~ Asepsis.
In Modern surgery the life of the
patient and the result of the op-
eration depends as much upon
the precautions against infection
as upon operative skill on the
part of the surgeon.

Study pathology, and practice
Asepsis by the aid of Antiseptics.
The details of the technique and the
rules of practice laid down in this
little book will do much good, and
I wish that it may find its way into
the hands of every physician.

The arrangement of the text affords
ready reference, containing as it
does a copious index both of Authors
quoted, and of subjects treated.

2715 Locust. St. A. C. Bernays.

CONTENTS.

CHAPTER I.

History—From Earliest Times to the Beginning of the Christian Era, 3

CHAPTER II.

History—From the Christian Era to the Beginning of the Eighteenth Century, - 12

CHAPTER III.

History—From the Beginning of the Eighteenth to the First Six Decades of the Present Century, 23

CHAPTER IV.

History—From the Advent of Lister to the Present Time, 36

CHAPTER V.

The Products of Vital Cellular and Bacterial Activity, 46

CHAPTER VI.

Infection, Susceptibility and Immunity, - 59

CHAPTER VII.

Antiseptics and Their Relative Value, - 81

CHAPTER VIII.

Antiseptics—Their Use and Value in General Medicine, - 220

CHAPTER IX.

Antiseptics—Their Value and Use in Surgery, 234

CHAPTER X.

Antiseptics—Their Value and Use in Obstetrics and Gynecology, - - - 257

CHAPTER XI.

The Essentials of Antisepsis and Asepsis, - - - 273

INDEX.

Acetanilid, 94.
Acetic acid, 49, 95, 96.
Acetic fermentation, 33.
Acetone, 96.
Acetyl-para-amido-salol, 187.
Acquired immunity, 64, 73, 74, 75 76, 77, 78, 79, 80, 81.
Acrolein, 213.
Action of antiseptics, 92, 93, 94.
Action of blood and tissues upon parasitic organisms, 222.
Adeps lanac hydrosus, 161.
Advantages of antiseptics, 38, 39.
Alabastrine, 164.
Alcohol, 97.
Alkaloidal bases of dead body, 55.
Alkaloidal bases of decomposed brains, 56.
Alkaloidal bases of decomposed blood, 54.
Alkaloidal bases of decomposed meat, 55.
Alkaloidal bases of liver-sausage, 55.
Alkaloidal bases of moldy corn-meal, 56.
Alkaloidal bases of poisonous cheese, 56.
Alkaloidal bases of putrid yeast, 54.
Alumn, 97.
Alumnol, 98.
Aluminic acetate, 97.
Aluminic chlorid, 97.
Ammido-para-acet-phenetidin, 169.
Ammonia, 99.
Ammonic carbonate, 99.
Ammonic chloride, 99.
Ammonic fluo-silicate, 99.
Ammonic ichthyo-sulphonate, 208.
Ammonic sulphate, 99.
Anacrobic germs, 48.
Analgessin, 102, 103.
Ancient system of medicine, 7.
Anhydro-ortho-sulphaminic benzoic acid, 181.
Anilin dyes, 100.
Anilin oil, 101.
Animal alkaloids, 31, 45, 50, 51.
Anisic acid, 101.
Annidalin, 101.
Anthrarobin, 102.
Anthrax, 41, 42.
Anthrax spores, 130, 131, 133.

Anthrax poison formed by germs, 56.
Anticholerine, 42, 57.
Antifebrin, 94.
Antipyrin, 102, 103, 339, 346.
Antisepsin, 103.
Antisepsis, 5, 8, 81.
Antisepsis among Egyptians, 9, 10, 11.
Antisepsis among Greeks, 11.
Antisepsis among Jews, 11.
Antiseptics for internal and external use, 227, 228.
Antiseptics, mode of action, 92, 93 94
Antiseptics, value and use in general medicine, 220.
Antiseptics value and use in obstetrics and gynecology, 257.
Antiseptics, value and use in surgery, 234.
Antiseptol, 103.
Antizymotic, dry, 6.
Arbutin, 103, 104, 105, 155.
Argent nitrate 197.
Argol, 212.
Aristol, 105, 346.
Arsenious acid, 105.
Asaprol, 106
Asepsis, 6, 83.
Asepsis dependent upon antisepsis, 83.
Aseptin, 106.
Aseptol, 106, 107, 208.
Assyrians, 9.
Attenuated cultures, inoculation of, 42.
Auric chlorid, 153.

Bacillus subtilis, 141.
Bacillus tetanus, discovery of, 43.
Bacterial proteids, 50.
Bacteriology in diagnosis, 223.
Baric chlorid, 107.
Bases of dead body, 55.
Benzene, 107.
Benzoate of beta-naphtol, 109.
Benzoate of guaiacol, 110.
Benzoate of eugenol, 110.
Benzoic acid, 108.
Benzoic sulphimide, 181.
Benzol, 107.
Benzo-naphtol, 109.
Benzo-phenoncide, 110.
Benzosol, 110.
Benzoyl-eugenol, 110.
Benzoyl-guaiacol, 110.
Benzoyl sulphonic-imide, 181
Betanaphtol, 156, 165.
Betol, 111.
Bichloride of mercury, 132.
Birth of antiseptic era, 37.
Bismuth. subnitrat., 346.
Blood, action upon germs, 63, 66 67, 68, 69, 70, 71, 72, 73, 84.
Blood serum therapy, 73, 84, 85.
Blood serum, germicidal power, 63.
Boiling point, effect on putrefaction, 7.
Boracic acid, 112.
Boric acid, 112, 345.
Borax, 111.

Borneol, 212.
Brains, alkaloidal bases of decomposing, 56.
Brewer, first, 8.
Bromin, 129.
Bromoform, 114.
Bromol, 115.
Bromophenol, 115, 130.
Butyric acid, 49, 116.
Butyric acid fermentation, 33.

Calcic beta-naphtol-alpha-monosulphonate, 106.
Calcic chlorid, 116.
Calcic hydroxid, 116.
Calcic hypochloiite, 116.
Calcium salicylate, 118.
Camphene, 212.
Camphor, 118.
Camphylene, 164.
Carbolic acid, 32, 33, 43, 345.
Carbonate of ethyl and phenyl, 151.
Carvacrol, 126.
Caustic soda, 199.
Cell products, 45, 47, 48, 49.
Cell products, effects in causation of disease, 45.
Cheese, poisonous, 54.
Chinese, 9.
Chinoline, 126.
Chloral, 129.
Chlorate of potash, 174.
Chloride of lime, 116, 129.
Chlorine, 127.
Chlorine in internal medication, 129.
Chloroform, 130.
Chlorphenol, 130.
Chloro-phenol, 130.
Cholera, 43.
Cholera bacillus, 43.
Cholera, discovery of germs, 43.
Cholera, poison elaborated by, 56.
Cholera stools products, 54.
Chrysarobin, 131.
Chromic acid, 131.
Cinnamyl-eugenol, 150.
Circumcision, 11.
Citric acid, 132.
Civilization of ancient Egyptians, 10.
Classification of micro-organisms, 25, 43, 49.
Cleaning of patient, 258
Cleaning of instruments, 290.
Coal tar, 27, 120.
Coal tar, preservative properties, 27, 120.
Coal tar saponine, 120
Coffee infusion, 132.
Cold, preservative effects, 6.
Cold, effects on germs, 86, 87.
Columbus, 4.
Condition for cell life, 315.
Contagium animatum of Pasteur, 35.
Corrosive sublimate, 132, 135, 345
Creolin, 142.
Creosol, 144.
Creosot, 144.
Creosotal, 144.

Cresalol, 169.
Cresin, 145.
Cresol, 144, 146.
Cresoliodide, 146.
Cresylic acid, 147.
Cupric chlorid, 147.
Cyanide of zinc and mercury, 346.
Cymene, 212.

Dark ages, 13.
Decomposing blood, 54.
Decomposing meat, 55.
Decomposition, organic, 6.
Decreased mortality of antiseptics, 38, 39.
Dehydro-di-methyl-phenyl-pyrazine, 102.
Dependence of asepsis upon antisepsis, 83.
Dermatol, 147.
Disinfection oil, 188.
Desozy-alizarin, 102.
Dessication, effect on germs, 90, 91.
Development of germs, 85.
Diapterin, 148.
Di-methyl-oxy-quinizine, 102.
Diphtheria, 43.
Diphtheria, discovery of germ, 43.
Diplococcus pneumoniæ, 40, 42.
Discovery of micro-organism, 19.
Discovery of yeast plant, 28.
Discovery of spores, 31.
Disinfection, control disinfectious diseases, 222.
Disinfectol, 148.
Di-iodo-para-phenyl-sulphonic acid, 205.
Di-iodo-resorcin-mono-sulphonic acid, 172.
Di-iso-butyl-ortho-cresol-iodid, 151.
Di-methyl-benzene, 218.
Drainage, 308.
Drainage, first attempts, 17, 24, 26.
Dry heat, effect on germs, 90, 91.
Dry pulverulent dressing, 314.
Dupre, 53, 54.

Earliest record of antiseptic practices, 9.
Earliest record of medicine, 7.
Effect of ingestion of putrid matter, 54.
Egyptian civilization, 10.
Egyptian medicine, 10.
Egyptian priest-physicians, 10, 11.
Egyptians, 9, 10, 11.
Elementary principles of modern midwifery, 265.
Electricity, effect upon germs, 91, 92.
Embalming, 9, 10.
Embalming, a crude attempt at asepsis, 10.
Essentials of antisepsis and asepsis, 273.
Essential oils, 149.
Ether, 149.
Eucalyptene-di-chlorid, 150.

Eucalypteol, 150.
Eucalyptol, 140.
Eugenic acid, 150.
Eugenol, 150.
Euphorin, 150.
Europhen, 151.
Exalgine, 151.

Fatty acids, 49.
Fermentation, 4, 5, 8, 20, 22, 30.
Fermentation, acetic, 33.
Fermentation, entyric, 33.
Fermentation, putrefactive, 5.
Fermentation, vinous, 33.
Fermentation, Bell's theory, 27.
Fermentation, Gay Lussac's theory, 28, 29.
Fermentation, Mayow's theory, 27.
Ferrichlorid, 152.
Ferrous sulphate, 152.
Feuerbringer's method, 262.
Formalia, 152.
Formic acid, 152.
Fowler's solution, 173.

Gallic acid, 152.
Germ effect in causation of disease, 45.
Germ products, 45, 48, 49, 50.
Germ theory of disease, 33, 34, 35 37, 44, 46, 47.
Germicidal effect, 81, 82.
Germicidal power of blood not due to phagocytes, 67.
Glanders, 22.
Glycerin, 153.
Gluside, 181.
Glucusimide, 181.
Gold chlorid, 153.
Gonococcus, discovery of, 41.
Gonorrhea, 41.
Gravitation, 3.
Greeks, 11.
Guaiacol, 153.
Guards against gastric-intestinal infection, 61.
Guards against infection through blood channels, 61.
Guards against infection through lymph channels, 61.

Heat as sterilizer, 285.
Helenin, 154.
Heliotropsin, 172.
Hydrochinone, 155.
Hydrofluoric acid, 156.
Hydrofluosilicic acid, 156.
Hydrogen dioxid, 155.
Hydrogen peroxid, 155, 346.
Hydronaphtol, 156, 346.
Hydroquinone, 104, 155.
Hydroxyl, 155.
Hydroxyl-benzene, 118.

Iceland, 4.
Ichthyol, 208.
Immunity conferring albumose of anthrax, 56.
Immunity from disease, 62, 63, 64.
Immunity, natural, 64, 65.

Immunity, artificial, 64, 73, 74, 75 76, 77, 78, 79, 80, 81.
Immunity, racial, 64.
Indol, 157.
Infection by inhalation, 60.
Infection through circulatory system, 60.
Infection through lymphatic system, 60.
Infection through intestinal mucous membrane, 59.
Infection through respiratory mucous membrane, 60.
Infection through skin, 59.
Influenza, 43.
Influenza, discovery of germ, 43.
Ingestion of putrid matter, effect, 54.
Iodide of potash, 175.
Iodine, 129, 157, 345.
Iodine in internal medication, 129.
Iodin-trichlorid, 157.
Iodo-boro-thymolate of zinc, 103.
Iodo-di-iso-butyl-ortho-cresol, 151.
Iodoform, 158, 345.
Iodol, 159, 346.
Iodophenacetine, 159.
Iodophenin, 159.
Iodozone, 160.
Irrigation, 28, 303.
Iso-naphtol, 165.
Izol, 160.

Jews, 11.
Jewish priest physicians, 11.
Jewish vandage in Egypt, 11.

Koch's discovery of pathogenic germs, 40.
Koch's discovery of specific origin of anthrax, 41.
Koch's discovery of bacillus anthracis, 41.
Koch's treatise on traumatic infectious diseases, 41.
Koch's discovery of typhoid germ, 42.
Koch's discovery of cholera spirillum, 43.
Koch's inoculations of attenuated cultures, 42.
Koch's introduction of mercuric chlorid, 42.
Koch's indroduction of solid culture media, 49.
Koch's introduction of plate method for pure cultures, 49.
Koch's introduction of gela'in media as a means of classification of germs, 49.

Lactic acid, 161.
Lanolin, 161.
Laurinol, 118.
Lead chlorid, 160.
Lead tiophen-sulphonate, 215.
Leprous tubercle, 41.
Leucomaines, 45, 50, 51, 52, 230.
Lime water, 116.
Liquor antisepticus, 142.

Listerism, 267.
Lister's extension of discovery of Schwann and Pasteur, 40.
Lister's renewed allegiance to carbolic acid, 43.
Lister's surgical dressing, 41.
Losophan, 162.
Lysol, 162, 263.
Lunar caustic, 197.

Malachite green, 100.
Malarial disease, 42.
Malic acid, 163.
Meat, poisonous, 52.
Medicine among early Egyptians, 10.
Mercury, 163.
Mercuric chlorid, 132, 345.
Mercuric chlorid action as an antiseptic, 264.
Meta-di-hydro-oxy-benzene, 179.
Meta-di-oxy-benzene, 179.
Methyl-blue, 100, 163, 177.
Methyl-yellow, 100
Methyl-violet 100, 177.
Methyl-acet-anilid, 151.
Methyl pyrocatechin, 153.
Methylene-blue, 100.
Method of embalming, 9.
Method of staining, 49.
Methozin, 102.
Microbes, 4.
Micro-organisms causing morbid conditions, 226.
Micro-organisms, classification of 43.
Modern progress in medicine, 12.
Moist heat, effect on germs, 87, 88, 89.
Monochlorphenol, 130.
Morbid conditions caused by micro-organisms, 220.
Morphia hydrochlorate, 164.
Mortality, decrease due to antisepsis, 38, 39.
Moldy cornmeal, effect of, 56.
Mustard, 346.
Mustard as a means of sterilization, 338, 339.

Napthalene, 164.
Naphtalin, 164.
Naphtalol, 111.
Naphtol, 165, 321.
Naphtosalol, 111.
Naphtyl-alcohol, 165.
Natural processes combated, 8.
Nature lost sight of by early physicians, 7.
Nature, healing power of, 13, 15, 16, 17, 20, 156.
Nitric acid, 166.
Nitrous acid, 166.
Norsemen, 4.

Office of practitioner of antiseptic surgery, 6.
Oil of mustard, 339.
Oil of turpentine, 339.
Oleic acid, 166.
Olive oil, 167.
Organic decomposition, 6.

Ortho-bromo-phenol, 115.
Ortho-cresol iodid, 146.
Ortho-phenol, 106.
Ortho-phenol-sulphonic acid, 100.
Ortho-phosphoric acid, 171.
Oxalic acid, 167, 264.
Oxychinaseptol, 146.
Oxygen, 6, 167.

Para-amido-anisol, 213.
Para-cresolal, 169.
Para-cresolic salicylate, 169.
Para-dioxy benzene, 155.
Para-mono-acetanilid, 103.
Para-mono-brom-phenyl-acetamid, 103.
Pasteur's investigation, an aid to Lister, 34, 40.
Pasteur's investigation, result of, 34.
Peroxide of hydrogen, 263, 264.
Phagocytosis, 45, 63.
Phenazon, 102.
Phenic acid, 118.
Phenocoll, 169.
Phenol, 118.
Phenolid, 170.
Phenosalyl, 170.
Phenol sulfonic acid, 208.
Phenyl-acetamid, 94.
Phenyl-alcohol, 118.
Phenyl-ethylic-urethane, 151.
Phenyl-dimethyl-pyrazolon, 102.
Phenyl-hydrate, 118.
Phenyl-hydroxid, 118.
Phenyl-salicylate, 186.
Phenyl-urethane, 151.
Phyloxera, 34.
Picrol, 172.
Piperonal, 172.
Plasmodium malariæ, 42.
Pneumotosine, 57.
Poisoning, acute alkaloidal, 230.
Poisonous cheese, 54.
Poisonous products of germs, 57, 58.
Poisonous sausage, 53, 54.
Potassic acetate, 173.
Potassic arsenite. 173.
Potassic bromid, 173.
Potassic carbonate, 174.
Potassic chlorate, 174.
Potassic chromate, 174.
Potassic cyanid, 174.
Potassic di-chromate, 173.
Potassic hydroxid, 175.
Potassic iodid, 175.
Potassic permanganate, 176, 264.
Predisposition of disease, 61.
Preparation of dressing, 293.
Preparation of hands, 301.
Preparation of ligatures and sutures, 296.
Preparation of sponges, 298.
Priest-physicians of Egypt, 10, 11.
Priest-physicians of Hebrews, 11.
Primitive medicine, 7, 8.
Principia of Newton, 4.
Propionic acid, 49.
Ptomaines, 45, 50, 51, 52, 230.
Ptomaines, determination of

chemical nature, 53.
Ptomaines, nature of, 56.
Puerperal infection, causes of, 271.
Putrefaction, 48, 29.
Putrefaction, germ theory of, 5.
Putrefaction but a form of fermentation, 8.
Putrefactive alkaloids, 50, 51.
Putrefactive fermentation, 6.
Putrefactive germs, 6.
Putrid matter, effect of ingestion, 54.
Putrid matter, chemical nature of poisonous principles, 54.
Putrid yeast, 54.
Pyoktanin, 100, 177.
Pyroligenous acid, 96.
Pyrozone, 179.
Pyrrol, 159.

Quickine, 178.
Quinine, 179.
Quinol, 155.
Quinoline, 126.

Relapsing fever, 41,
Relapsing fever germ, discovery of, 41.
Relative value of various germicidal agents, 134.
Renaissance, 13.
Resinol, 180.
Resorcin, 179.
Resorcinol, 179.
Resopyrin, 179.
Retinol, 180.
Rosanilin, 100.
Rosinol, 180.

Saccharine, 187.
Saccharomyces cerevisiac, 6.
Salacetol, 182.
Salicylate of phenol, 111.
Salicylate of phenocoll, 186.
Salicylacetol, 182.
Salicylic acid, 183.
Salicylamid, 182.
Salinaphtol, 111.
Salocoll, 169, 186.
Salol, 111, 186, 321, 346.
Salophen, 187.
Salt, 199.
Sanitas, 188.
Saprol, 188.
Sausage poisons, 53, 54.
Sennine, 171, 189, 218, 319, 321, 326, 328, 344, 345.
Sepsine, 31, 54.
Sepsis, 6.
Silver nitrate, 197.
Skatol, 198.
Smoke, 198.
Soda, 199, 286.
Sodic carbonate, 199. 286.
Sodic chlorid, 199, 287.
Sodic di-iodo-salicylate, 200.
Sodic di-thio-salicylate, 200.
Sodic hydroxid, 199.
Sodic meta-borate, 202.
Sodic paracresotate, 200.
Sodic salicylate, 185.

Sodic silico-fluorid, 156.
Sodic sozoiodolate, 200.
Sodic sulphite, 201.
Sodic sulpho-carbolate, 201.
Sodic tetra-borate, 112.
Sodic thiophen-sulphonate, 202.
Sodic thio-sulphate, 202.
Sodium ichtyo-sulphonate, 208.
Sodium thiophen-sulphonate, 215.
Solocol, 204.
Solutol, 203.
Sozal, 204.
Sozolic acid, 106, 208.
Sozoiodol, 204.
Spirochete obermeieri, 41.
Spores, 31, 41.
Spores, Cohn and Koch's investigation, 41.
Spores, Robin and Perty's, 31.
Staphylococcus pyogenes albus, 258, 259, 261, 262.
Staphylococcus pyogenes aureus, 140, 141, 259, 261, 262.
Staphylococcus pyogenes citrus, 258.
Steresol, 206.
Sterilization of dressing, 258, 293.
Sterilization of hands, 301.
Sterilization of instruments, 258, 290.
Sterilization of ligatures and sutures, 296.
Sterilization of sponges, 298.
Sterilization of wound, 288.
Streptococcus pyogenes, 258.
Styracol, 207.
Styron, 207.
Subgallate of bismuth, 147.
Sulphaminol, 207.
Sulphaminol creosote, 208.
Sulphaminol eucalyptol, 208.
Sulphaminol guaiacol, 208.
Sulphaminol menthol, 208.
Sulpho-carbolic acid, 106, 208.
Sulphonic acid, 106.
Sulphuric acid, 209.
Sulphuric dioxyd, 209.
Sulphuric acid, 210.
Sulphurous acid, 31, 209.
Sulphurous acid gas, 209, 211.
Suppuration, 227.
Susceptibility to disease, 62.

Tannic acid, 211.
Tannine, 211.
Tartaric acid, 212.
Tarwater, 27, 28.
Temperature, effect of variations on germs, 86.
Terebene, 212.
Terpilene, 212.
Terpine, 213.
Tetanin, 56.
Tetanus, 43, 45.
Tetanus, discovery of germ, 43, 56.
Tetanus poison elaborated, 56.
Tetra-borate of sodium, 112.
Tetra-hydro-para-chinonisol, 213.
Tetra-hydro-para-methyl-oxy-chinolin, 213.
Tetra - methylo - diapsido-benzo -

phenoncide, 110.
Tetra-iodo-pyrrol, 159.
Tetra-methy -thionin, 162.
Thalline, 213.
Thilanine, 213.
Thiol, 214.
Thiophen, 215.
Thiophen-di-iodid, 215.
Thio-oxy-diphenylamin, 207.
Thio-resorcin, 215.
Thymol, 216.
Tinchlorid, 217.
Tobacco-smoke, 217.
Toxalbumen, 50, 230.
Toxines, 50, 51.
Tri-brom methane, 114.
Tri-brom-phenol, 115.
Tri-chlor-aldehyde, 127.
Tri-chlor-methane, 130.
Tri-chlor-phenol, 130.
Tri-iodo-methane, 158.
Tri-iodo-meta cresol, 162.
Tuberculin, 42, 57.
Tuberculosis, 42.
Tuberculosis, discovery of bacillus of, 42, 43.
Tumenol, 217.
Typhoid bacillus, 141.
Typhoid fever, 42, 43.
Typhoid fever germ, discovery of, 42.
Typhoid bacillus poison elaborated, 56.
Typhotoxines, 56, 57.
Tyrotoxicon, 56.

Universal gravitation, 3.

Valerianic acid, 49, 217.
Vinegar, 96.
Vinous fermentation, 33.
Virtue of antiseptic principles, 8.

Washing soda, 199.
Woodvinegar, 96.
Wounds, treatment of, 37, 38.

Xylene, 218.
Xylol, 218.

Yeast plant, 6, 28.

Zinc boro-thymo-iodid, 100.
Zinc chlorid, 218.
Zinc mercuric cyanid, 218.
Zinc sozoiodolate, 219.
Zinc sulphate, 219.
Zinc sulpho-carbolate, 219.
Zinc sulphydroxid, 220.

AMBROSE PARÉ, THE FATHER OF FRENCH SURGERY, DEMONSTRATING THE USE OF LIGATURES.

ANTISEPSIS AND ANTISEPTICS.

I.—History.

From Earliest Times to the Beginning of the Christian Era.

No great discovery, no epoch-making invention is or ever has been the product of one brain. Inklings of the truth have illumined the minds of others than the so-called discoverers or inventors; only in the ripeness and fullness of time is the actual birth of the fact culminated and then by some one who, standing head and shoulders above the common throng, perceives the light and enlightenment of coming ages and proclaims the truth to his fellow man. Newton was not the first to observe that all unsupported bodies fell earthward and not skyward, nor indeed was he the first to suspect the existence of that mutual attraction between all matter of the univer e which we term universal gravitation. This had been suspected and supposed by philosophers for ages, but Newton first elucidated and demonstrated the primary laws by which its action was governed—

this alone was sufficient to render his "Principia" immortal. Columbus was not the first individual to suspect the existence of a new world, nor indeed to actually discover it; others had gone before him, others had been as brave and daring, others strong in the courage of their own convictions had accomplished as much as he, but the time was not ripe, the world was not ready to profit by their works until the coming of Columbus, who owed so much to the prior discoveries of the brave and hardy Norsemen—for he had undoubtedly made himself familiar with their deeds and discoveries during his voyages to Iceland. It was the good fortune of Columbus to have his discoveries followed up and developed by others than himself. Just so Lister is neither the discoverer nor inventor of antisepsis, though to his work, to his investigations and to his tireless energy the world owes a greater debt of gratitude than to any other single individual. So then, mindful of the fact that Lister was not the discoverer of the agency of microbes in the causation of fermentation, putrefaction, still as the originator and elaborator of the first well defined and systematic method of combating putrefactiv fermentation he rendered such service to mankind as to hand his name down to posterity as that of one to whom we owe an incalculable debt of gratitude. It matters not that his methods have been and will probably yet be radically modified, the broad and general principles upon which they are founded remain the same, and indeed will probably endure as long as surgery is a branch of the healing art.

Hence, though true antiseptic surgery is much older than Lister himself, this can in nowise detract from the debt which humanity owes to him.

This subject, involving as it does the history of progress in all branches of medical science and intimately associated with the life history of the theories of fermentation as well as the discovery and development of the microscope, is a most voluminous one and must be traced by degrees and stages.

Fermentation and putrefaction are strictly analogous processes or conditions, induced by the presence of minute living organisms, which highly complex organic bodies undergo when subjected to proper conditions of heat, moisture and atmosphere. It has been satisfactorily demonstrated that putrefaction and fermentation only supervene when particles or organisms from without gain access to the putrefying or fermenting mass, whether that be dead or living tissue. This germ theory of putrefaction is the only view at the basis of antiseptic surgery and of which the exhibition of antizymotic drugs, or antiseptics, is only one feature. Then antisepsis consists of such management of a case as to prevent the occurrence of putrefaction in any part concerned. When this has been attained, surgery becomes something entirely different from what it used to be and both injuries and diseases formerly regarded as formidable or hopeless, progress surely and quietly toward recovery. This germ theory declares that the putrefaction of organic substances under so-called atmospheric influence is nct effected, as formerly supposed, by the

oxygen of the air but by living organisms derived from germs floating in the air or as a constituent of dust, the first step towards the establishment of this theory was the discovery of the yeast plant (Saccharomyces cerevisiæ) by Cagniard de la Tour in 1836. Then we may understand by the term sepsis the existence of a condition in which infectious or putrefactive germs are present, asepsis, the entire absence of such germs and antisepsis the condition secured by any method whereby the growth and fermentative action of these peculiar and lower forms of organic life are more or less impeded, whether they are totally destroyed or simply rendered innocuous. An antiseptic or antizymotic drug is one which has the power of preventing putrefactive decomposition and whose power is evidenced by the ability to prevent the development of bacteria or micro-organisms in a medium suitable or favorable to their growth.

It then becomes the office of the practitioner of antiseptic surgery to withdraw all obstacles to those operations of Nature which naturally tend to become reparative in effect, since it is nature who heals the wound, while the surgeon prevents any interference with her normal efforts to that effect.

The methods of preventing organic decomposition depend entirely upon the removal of some one or more of the conditions necessary to the accomplishment of the process, no matter by what means effected, for instance, by the extreme elevation or depression of temperature. The preservative effects of cold are well known; animals have been found undecomposed, in the ice of Sibe-

ria, belonging to extinct species and which must have heen embalmed and enveloped in the ice for ages. A boiling temperature coagulates albumen, kills organisms and arrests putrefaction. These two operations are probably the most familiar and common of the processes by which antisepsis may he secured, hut are not altogether adapted for surgical use, for reasons which are obvious. With this brief preface we may proceed to the consideration and development of the subject in hand.

The most remarkable characteristic of the present age is its desire to connect itself with preceding ages; to learn how the things, which now are, grew and the origins from which they sprang. In science as elsewhere, one discovery grows out of another and cannot appear without its proper antecedent. In the earliest times of which we have any recorded history, mankind, as now, had recourse to the skill and art of the physician, for indeed, medicine is prohably as old as man himself. But naturally the system of medicine then in vogue was somewhat crude and ineffectual as compared with the status of the profession of the present day. Then, and indeed until comparatively recent times, the sole aim and object of the physician seemed to be the use of substances which would *make* a wound heal, *make* flesh grow and *make* it firm, to *make* a good cicatrix and to *make* a good recovery, as though the physician himself could exercise creative power. Amid all of these efforts nature was lost sight of, as was also the parts and functions which she must, and she alone can, perform in the healing of any wound. No attention

was given to the wound and its natural tendency to heal if uninterfered with; all natural tendencies were looked upon as vicious and as something to be combated. Nevertheless some bright minds, from time to time, realized the undesirability of interference on the part of the physician or surgeon and protested against the methods in vogue in no uncertain tones. This and this alone is the chief virtue of antiseptic principles that the natural operations of recuperation and repair are allowed to progrsss absolutely free from any extraneous or inhibiting condition.

Putrefaction is but one form of fermentation, hence the history of antisepsis and antiseptic snrgery is intimately associated with that of fermentation. We have no positive account of the first brewer but from history we glean the fact that his art must have been practiced and its products appreciated more than two thousand years ago, for Theophrastus lived and brewed nearly four hundred years before the Christian era. The art of making wine, beer and other fermented liquors possesses such an old history, until a very few years ago no one knew the reason, the true secret, of their formation, indeed the little knowledge of the subject then existing was purely the result of empirical observation, the *facts*, the *conditions* of success were known, but not the *reasons*. This is neither astonishing nor unexpected when we consider that the microscope had to be invented and perfected before definite and positive information regarding the phenomena of fermentation and putrefaction could be obtained.

The earliest records of man's efforts to overcome the ravages of time and the effects of decay are to be found in the history of Egypt. Among the Egyptians these efforts took the form chiefly, of embalming the dead, which with them was a religious duty. The process demands a certain amount of knowledge regarding the preservative qualities of the various gums, aromatics and spices. After the decease of a person the first step toward embalming him was the removal of the brain and abdominal viscera; the rudimentary knowledge of anatomy possessed at this time was evidenced by the crude means of removal of these objectionable viscera. After this was accomplished the body was thoroughly washed and cleaned, aromatics and spices being lavishly used; then for seventy days was the body subjected to the action of a solution of salt when it was removed, and after being covered with gum or bitumen, wrapped or swathed in cloths in which various gums and spices were liberally enfolded. The body, in a suitable receptacle, was then placed in the tomb to await *unchanged* the summons to the Elysian fields of Aahlu. Here we have, crude as it is, one of the first systematically recorded attempts at the exclusion of what was dimly thought to be the cause of decay, what is modern asepsis but a more elaborate, finished and successful attempt to secure the same results?

We are more or less familiar with the skill displayed by the Chinese in the manufacture of gunpowder and silk, we have read of the wonderful records of astrological science in which the ancient Assyrians sufficiently

attest their knowledge hundreds of years before the time of Christ; we stand amazed at the marvelous civilization of the ancient Egyptians with their comprehensive schemes of irrigation and agriculture and their accomplishments in the arts and manufactures, producing fabrications which to this day are only excelled by nature herself. We are also familiar with those master-pieces of engineering ingenuity, hoary with age, and offering an archetype which none have since followed and the processes of whose construction none have been able to fully explain. These wonderful examples of skill, genius and ability substantiate, beyond peradventure, the fact that these nations had attained an enviable degree of civilization and a high degree of intellectual development. With a proper understanding of the powers, aptitudes and possibilities of the ancient Egyptians before us, it seems more than incongruous that in their history the medical art was not permitted a commensurate enlightenment and erudition or that a degree of perfection was not attained in keeping with their progress in the several phases of their marvelous civilization. The art of embalming presents such remarkable results that we are constrained to place it among the greatest of the achievements of this wonderful people. In medicine and the collateral branches of science the ancient Egyptians showed as great aptitude and as much natural competency as in other matters; but the medical art was shackled by mystic practices and amalgamated to irrational forms of worship by the governing priestly classes. They were ever ready

to construe independence of thought and action as a threatened encroachment upon their own arrogated prerogatives or powers; their action and power rendered any attempt at weakening or prejudice of their investitures impossible.

Among the Greeks we find some inklings of the truth as early as the middle of the fifth century before Christ and at that time by Empedocles, who had vague suspicions of the existence of contagia and miasma in the atmosphere. Agrigentum had suffered a pestilential plague for several seasons when Empedocles noticed that it only originated when the sirocco prevailed and this blew from the south-east where it came through a narrow gorge; Empedocles walled up this gorge and Agrigentum suffered no more,

Among the Jews we find, from the book of Leviticus, a primitive appreciation of the nature of some diseases; contagion was dimly understood and also the purifying effects of fire, but no reason for this was known. It is probable that the Hebrews, during the period of their bondage in Egypt, learned many things from their taskmasters. Moses was educated at the court of Pharaoh and was deeply versed in the so called mystic lore of the period. The Jewish custom of circumcision, at least, must give us some feeling of respect for the methods of prophylaxis then prevailing, no matter how crude.

We discover, however, among the Jews the same tendency displayed by the Egyptians, that is the restriction of medicine to the priestly class, or Levites—

they took entire charge of medical affairs and associated them with their priestly functions. Their arrogance in such matters and their intolerance of all advancement which did not come through them is shown by the fact that in Salomon's time a work appeared, said to have been written by the sovereign himself; this work professed to teach how to treat disease by means of natural methods. It was seized and destroyed by the high-priest Ezechias, because he thought that it would damage the interests of the priests and trench upon the prerogatives of the Levite order.

This brings us down to the Christian era.

II—History.

From the Christian Era to the Beginning of the Eighteenth Century.

To quote the words of Dr. Pepper, in his presidential address to the Pan-American Medical Congress so recently convened at Washington, D. C.: "Modern medicine has made more progress in the past twenty years than in the whole of the twenty centuries preceding them!" Hence we can expect no remarkable strides in the history of antisepsis in the earlier days—nay, even centuries—of even civilization itself. Indeed, positive

advancement would be impossible without the invaluable aid of the microscope, upon whose precision and certainty all modern progress in such direction is based.

In the seventh century after the inauguration of the Christian era Paul d'Egineta lived and flourished. He condemned all measures used by physicians which tended to hinder the action of Nature. He also declared that we must attribute to Nature herself the successive changes presented by wounds in the process of repair. This is a distinct advance when compared with the previous opinions that a physician possessed and could exercise a modified form of creative power in the treatment of wounds and traumatisms.

Medicine, as was all learning, was plunged into the utter darkness of the ignorance and superstition of the so-called Dark Ages, only to revive in the Renaissance. Consequently it was nearly seven hundred years before even a faint glimmer of light pierced the Cimmerian darkness. The thirteenth century witnessed the birth of Rogerius, of Lanfranc and of Bruno, each one of whom bears an important relation to the development of those ideas which have culminated in modern antisepsis and asepsis. Rogerius vigorously protested against the use of any dressing which would antagonize in any way the natural operations of repair; he used only wine and honey, as local applications. Bruno instituted the practice of closing all incised wounds at once; wounds with loss of substance he caused to suppurate, unless the nerves were injured—*in which case he was afraid that putrefaction might cause spasm!* Here

we have a dim but certain appreciation of the reparative influence of the process of granulation, but, still more wonderful, a most accurate hint at the etiology of tetanus as elucidated by the science of to-day.

During the next two centuries, the fourteenth and the fifteenth, the obsolete methods of practice were almost wholly continued; in fact, this period was marked by little or no advancement of any value or practical importance.

De Vigo, in the fifteenth century, first enunciated his false and pernicious doctrine as to the poisonous nature of gunshot wounds. Noticing the frequent infection of open and exposed wounds, he ascribed the effects observed to the presence of air and declared that access of air to the wound was, *per se*, highly objectionable. He made use of various powders as dressings, some of which were undoubtedly antiseptic in their nature,—not that he knew of the presence and existence of such germs as cause putrefaction, or the germicidal virtues of such agents as he used, but that empiricism, experience, had taught him that benefit followed their application.

In 1542, Michel Ange Blondus discarded all of the surgical dressings in use at that time and advocated the use of water for such purposes. After arresting hemorrhage and removing foreign bodies he applied dressings which were soaked in water.

From this period begins the real history of the beginnings of modern treatment. The two most influential persons in laying the foundation of such methods were

Paracelsus and Pare. Phillipus Aureolus Theophrastus Paracelsus Bombastus was born at Einsiedeln, near Zurich, the year following the discovery of America—in 1493. He spent the early part of his life as a teacher of surgery at Basle. In the treatment of wounds he aimed solely at *aiding*, and not combating, Nature. He strenuously insisted that Nature alone was competent for the task of repairing wounds, that non-interference was the best policy. He believed in the existence of a juice in the body which kept the tissues in health and in proper repair when injured. In his opinion the office of the surgeon was to prevent any alteration in this liquid, which might result from contact with the air or other accident. He thought that Nature was usually sufficient for this, as was to be seen in the wounds of the lower animals,—the essential thing, he declared, was non-interference with Nature. His use of medicaments was only for the preservation of this juice and the prevention of its corruption or putrefaction. It is known that he made use of silver wire sutures and bathed or injected wounds with a solution of Plumbic acetate (Liquor Saturni).

Ambroise Pare (1509-1584) adopted these views. He mentioned a number of topical applications; his great aim was to keep the part at rest. Jeannel, in his work "*De l'Infection Purulente*," quotes passages from Pare which show that he attributed the fever which accompanies wounds to a putrefaction of pus. He was thoroughly impressed with the fact that the office of the physician was to assist Nature, for he says: "Or ceste

premiere et generale indication est parfaite par nature comme le principal agent, et par le chirurgien comme ministre de nature; et si nature n' est forte, le chirurgien ne pourra venir a sa fin pretendue." Moreover, he looked upon *pure* air as beneficial to a wound and to the patient; but the air of sick-rooms and camps he declared to be loaded with miasms and therefore very dangerous, —*it is the miasms in the air rather than the air itself which prove dangerous, he concluded.* This was a remarkably accurate, though crude, statement of the basis of antisepsis and modern antiseptic treatment three hundred years before its birth! Thanks to the writings, teachings and influence of these two men, old ideas began to give way to the newer and truer view that Nature is the only healing power and that all that human skill and knowledge can do is to remove anything which interferes with the natural operations of repair. Pare looked especially to the constitution, strengthening it and removing local disturbing causes in accordance with the time-honored teaching of "*Tolle causam.*"

Jean Andre Delacroix (1573) was one of the most successful surgeons of his time; he adopted, to a certain extent, the views just related in regard to the powers of Nature and the office of the physician. He used antiseptic substances largely, indeed he strongly recommends such mild antiseptics as the ethereal oils and alcoholic substances. After arresting hemorrhage and removing foreign bodies, it was his custom to wash a wound with a detergent liquid and then apply plasters composed chiefly of pitch and oil of turpentine. The

results which he obtained by his methods were exceptionally good.

Francois Arcaeus (1574) simplified exceedingly the existing surgical methods, indeed his was the simplest of methods; it is remarkable for its close approach and likeness to the modern procedure. After arresting hemorrhage and removing foreign bodies he washed the wound with alcohol or wine and myrrh and then secured coaptation by means of sutures—*leaving an opening, if necessary, which was kept patulous by means of a piece of lint.* He then applied a balsamic preparation. Here we have the first practical and successful attempt at systematic drainage of wounds. The methods of Arcaeus gave remarkable results—indeed, it is really a fair antiseptic method and is not far removed, in its general principles at least, from our modern idea of an aseptic one.

Wurtz (1596) lived in terror of what he believed to be the contaminating influence of air upon wounds. So far did he carry his fear of his bugbear that he kept the door of the sick-room tightly fastened while he changed the dressings as rapidly as possible.

Near the end of the sixteenth century Vicary made use of balsams and balsamic preparations for dressings and with excellent results.

The greatest and chiefest advances made during the sixteenth century were the reassertion, in no uncertain tones, of the part played by Nature as the principal agent and healing power in the process of repair, the relinquishment of all idea as to the power of the physician

in *making* flesh or tissue and the abandonment of the idea of "feeding" wounds. We note, during this period, the first recommendation to apply antiseptic substances to wounds; this was the result of the observation of the success attendent upon the use of such agents, as in the case of the balsam of Arcaeus which acquired great fame. It was during this century that the first declaration of the infectious nature of air, or its constituent impurities or contaminations rather, was made; also the first crude and somewhat grotesque attempt to exclude air and its infectious principles from wounds. We observe also, at this time, the first attempt to drain wounds of the morbid products and secretions upon which pyogenic and pathogenic micro-organisms flourish. Such methods were, of course, largely the result of either chance, shrewd observation or empiricism for there was and could be no correct knowledge of the principles involved in such practices or in the attainment of such results—in other words, lacking scientific precision and devoid of scientific armamentaria, systematic observation and study was almost an utter impossibility, hence the only recourse was empiricism and observation. Paracelsus, though correctly named Bombastus, rendered an incalculable service to medicine when he so scathingly denounced slavish adherence to old and obsolete methods of practice; he was among the first to assail, with dauntless intrepidity, the very teachings of Aristotle and others whose opinions and doctrines had prevailed for centuries—he was a revolutionist of a most pronounced type. Thanks to

him, many obsolete procedures were sent hurtling into the abyss of chaos and oblivion.

Magatus (1616) is among the first whom we note in the dawn of the seventeenth century. He thoroughly appreciated and insisted upon the importance of rest in the treatment of wounds. He revived the doctrine of the evil effects of air upon wounds; he claimed that the air was full of miasms which affect the parts with which they come in contact. This was indisputably proven, he thought, by the fact that a punctured egg began to decay immediately. Hence, acting in accordance with his beliefs, he seldom changed dressings for fear of the contact of air and consequent infection of the wound.

The discovery of the actual existence of micro-organisms may be said to have been made by Anthony Van Leeuwenhoek. In 1675 he observed, by the aid of a single lens, multitudes of animalculæ swarming in a drop of stagnant and putrid water which he had, by chance, placed beneath his glass. This is the very first recorded observation of such organisms and has passed into history as the incident of the discovery of the microbes. This same astute old scientist, in 1683, discovered small, motile bodies in the mucus of the mouth and gave clear and minute descriptions of their appearance and movements; he also discovered the existence of micro-organisms in the feces and in the tartar of the teeth. From his drawings and remarkably clear descriptions of the bodies there is very little reason to doubt that he saw what are known to modern bacteriology as bacteria and vibrions. While Leeuwenhoek

discovered such bodies he had no idea of the important role which the result of his discovery was to play in the practice of medicine in years to come. Nevertheless his discovery is a most important one, laying, as it does, the first substantial foundation for the subsequent discoveries upon which the whole of the modern practice is founded.

Robert Boyle, in 1676, made a most startling decl ration in his "Essay on the Pathological Part of the Physik," it was as follows:

"He that thoroughly understands the nature of ferments and fermentation shall probably be much better able than he that ignores them, to give a fair account of divers diseases (as well fevers as others), *which will perhaps be never properly understood without an insight into the doctrine of fermentations.*" (The italics are mine). When we consider that Leeuwenhoek had made his discovery only a year previously and that no ideas of the connection between micro-organisms, fermentation and disease had, as yet, been promulgated, this statement, so plainly and so unmistakably couched, seems to border upon the marvelously prophetic. Certainly in the domain of surgery, as well as that of general medicine, Boyle's surmise has been more than realized.

Richard Wiseman (1692) was a man of remarkably good views and practices. In the coaptation of wounds he advised the use of no violence. He declared that the process of agglutination is the work of Nature alone; that, since the blood is the natural glue, the physician must take care that it is good and support the patient's

strength. He made use of turpentine and cooling and astringent lotions as dressings and sprinkled powders over large wounds.

Sir John Colbatch (1698) made use of an aqueous solution of sulphurous acid; he recommended it as follows:

"It is an excellent medicine, being taken by way of prevention in infectious seasons; and I think if any medicine deserves that name this doth deserve to be called the true prophylacticon."

His *Novum Lumen Chirurgicum*, which appeared in 1704, was a most remarkable treatise—a new surgical light, indeed! He described a medicament which he used which gave results comparable only to the results attained by the true aseptic methods of the present time. Unfortunately he kept its composition a secret and concealed his method also, hence it has become lost to the world although the reliability and accuracy of the results attained thereby are sufficiently attested to insure their truth; furthermore, the graphic description which he gives of the progress of his cases could not have been imagined, at that time, by any one who had not seen and was not practically familiar with the facts. He describes with peculiar accuracy what we now call a typical aseptic course; nor can there be any doubt that he was familiar with the fact of the vascularization of the blood clot and its replacement by new tissue, precisely as has been described by Lister, the modern "Father of Antiseptic Surgery." In his preface he asserts that the methods of former times, and indeed of

his very own, were far from the best. He furthermore says, somewhat significantly, that: "The corruption of the nutritive juice cannot be performed without a sort of fermentation and it is the fermentation particularly that, fretting the fibres, causes inflammation in wounds and by entering into the blood and dividing its texture causes symptomatic fevers which frequently prove so fatal." What marvel of a man have we here! What a pity that he saw fit to retain a secret which would have caused his name to ring with praise through every age! The medical profession completely ignored the teachings and results of Colbatch and indeed, ultimately, almost forgot them entirely; so that his brilliant mind and his brilliant work made absolutely no impression upon the history of medical progress.

He also referred to the fact that in all wounds the patient was put on a low diet and, more often than not, blood was taken from him in large quantities, thereby greatly weakening him; he protested vigorously against such a policy, but to no avail.

Neudorfer thinks that Colbatch's powder must have been ammonic salicylate, on account of the smell of roses to which the latter refers. Its action is thus described by its user: "In all incised wounds, where my medicines have been soon enough used and no other application preceded, they are perfectly cured in a few days *without suppuration.*" He also observed the process of granulation and the organization and transformation of the blood clot into new tissue.

In the seventeenth century but little real progress

ANTISEPTIC SURGERY ON THE BATTLEFIELD.

was made by the medical profession. The attempt at exclusion of air from wounds and the insistance upon mechanical rest, which in themselves were not new ideas, were the chief points promulgated. True, we note the discovery of micro-organisms by Leeuwenhoek, the remarkable declaration of Robert Boyle and the highly creditable achievements of Sir John Colbatch, all of which transpired in this century, but these were brilliant individual exceptions—not one made a lasting impression upon the medical progress of the time, indeed they were hardly appreciated for more than a century. With these exceptions, the history of the seventeenth century is almost a step in retrogression when compared with the sixteenth century.

This brings us down to the eighteenth century.

III—History.

From the Beginning of the Eighteenth to the First Six Decades of the Present Century.

The eighteenth century is somewhat remarkable for its dearth of illustrious names in the history of antisepsis, for very little true progress has been made at all in that period.

Augustin Belloste (1700) reiterated the teachings of

Magatus, to whom he allied himself. He insisted more particularly upon coaptation—even of bony structures.

Parmanus (1706) made use of a lotion of his own by virtue of which he claimed to be able to "resist putrefaction, prevent ill accidents and take away the pain and inflammation of a wound." This he used in the treatment of all wounds, keeping the dressings moistened with it constantly and changing them every two or three days.

Anel (1706) in the same year published his method of evacuating abscesses by a process of aspiration which left no open wound—similar in fact to the method of removing blood from the chest which was originated by Delacroix in 1573.

Boerhaave (1720), so well known in the history of the development of the science of chemistry, claimed that the absorption of pus caused internal abscesses; this was a step in the direction of the somewhat more modern pyemia.

Col de Villars (1741) insisted that dressings should be frequently changed, in order to prevent putrefaction.

Heister (1753) made extensive use of balsams in order to remove anything that might hinder the natural processes, especially suppuration—which he classed as such. In order to remove the products of suppuration, which he correctly deemed unwholesome, he made use of drainage by means of openings and counter-openings.

Bilguer (1764) was accustomed to fill all of the recesses of a wound with an antiseptic substance and to lay over the wound a piece of lint which had been

dipped in an antiseptic solution. He decried the almost universal custom of promiscuous amputation which he inveighed mercilessly. Indeed, he claimed that amputation might be almost totally dispensed with and gave both facts and figures to uphold his teachings.

Dr. Pringle, in his *Observations on Diseases of the Army*, published in London in 1765, called the attention of the medical profession to the fact that cinchona bark, whether used in decoction or in powder, possessed the power of preventing putrefaction of flesh for a time. The peculiar antiseptic qualities of cinchona and quinia have been more recently investigated and confirmed by Mayer, Pavísi, Hallier, Herbst, Polli, Binz and Bochefontaine.

Percival Pott (1768) sealed wounds very effectually in cases of compound fracture; but, at the same time, he insisted upon the maintenance of proper drainage by means of openings and counter openings.

The valuable preservative effects of sulphurous acid, its gaseous anhydride and its salts were known as early as the year 1771.

Muller (1773) made an attempt to classify the minute organisms which had been observed by others. Although Leeuwenhoeck first observed micro-organisms in 1675 it was nearly a century before an attempt was made to define the character of these organisms and to classify them. The knowledge of the subject possessed at this time was of a most rudimentary and elementary nature, hence Muller's work possesses naught of interest save

the fact that his was the first definite attempt at systematic classification.

Benjamin Bell (1784) made use of drainage in wounds, using leaden tubes for that purpose. He advised the employment of simple wound dressing, and also that all punctures of the skin, etc., should be valvular in character so as to prevent free access of air and objectionable matters to the wound.

In 1785, Lombard and Percy learned that a certain Alsatian physician possessed an infallible remedy for wounds. This infallible remedy proved to be pure river water which was used with magic phrases and incantations. Upon trial they found the water to possess the same efficacious virtues even when used without the magic phrases.

John Hunter (1792) taught that air was harmless as far as its influence upon wounds was concerned and that inflammation was due to an inherent tendency of wounds. He instituted researches on the healing of wounds beneath a scab—these researches were of much importance and interest. He also maintained that the process of healing must be left to Nature.

August Gottlieb Richter (1799) made use of openings and counter-openings for aid in the removal of pus.

And thus the century closes, without one discovery of importance, devoid even of one plausible and important theory. Down to the time of Priestley's discovery of oxygen, August 1, 1774, the deleterious effects of air, with few exceptions, were supposed to be due largely to temperature. Pare had declared it as

his belief that such effects were due to miasms; others looked upon the putrefaction of the discharges from the wound as the source of the evil and, as in the cases of Colbatch and Bilguer, succeeded sometimes in preventing such putrefaction. Mayow, in the latter part of the seventeenth century, declared that all fermentation was due to the "nitro aerial spirit" of the air—from his accurate description this "nitro-aerial spirit" was nothing more nor less than our modern oxygen. Benjamin Bell however, in the latter part of the eighteenth century, discarded all of these views, holding that the trouble was caused chiefly by "fixed air" (carbon di oxid). This view of Bell's, erroneous as it was, was developed and accepted by many, down until the very days of modern antiseptic surgery.

The first name of any interest to attract our attention in the inception of the present century is that of Von Kern. He (1809) made the claim that the only essentials in the treatment of wounds were cold water for the arrest of hemorrhage, warm water for dressing, some small pieces of lint, absolute mechanical rest and artificial heat. So popular did these views become that they were adopted by Von Walther of Bonn, Fritze of Prague and by Lister himself—indeed these methods of wound treatment continued in vogue in England until about thirty years ago.

The antiseptic and preservative properties of coal-tar were recognized by Chaumette (1815), by Guibourt (1833), by Sivet (1836), and by Bayard (1846). The famous panacea, tar-water, recommended so highly and

extravagantly by the celebrated Bishop Berkley has become a matter of history, although as far as practical use is concerned it sleeps the sleep of eternal oblivion.

Constant and intermittent irrigations of wounds was recommended by many throughout the present century but has been associated with the name of Langenbeck since the year 1839.

However, before the processes of fermentation and putrefaction could be thoroughly understood the microscope had to be invented and brought to some degree of perfection. Leeuwenhoeck, in 1680, found yeast to be a mass of globules but he had not the slightest conception of the fact that they were living organisms; this fact it remained for Caignard de la Tour to elucidate in 1836, which was the first step toward the establishment of the rudimentary tenets of what was to develop into the germ theory of disease. In the year 1836 Caignard de la Tour determined that the yeast plant (Torula cerevisiæ or Saccharomyces cerevisiæ) was a microscopic vegetable cell which, through increase in the number of cells, broke up sugar into alcohol and carbon di-oxid. With the death of the yeast cell or when, through any cause, it could increase no longer fermentation ceased.

In this same year Schulze proved that putrefaction was not due to oxygen. Gay Lussac had held that putrefaction did not take place in hermetically sealed vessels because the oxygen was excluded therefrom. This objection Franz Schulze met by admitting air which had been drawn through strong sulphuric acid to

boiled putrescible liquids; in which case putrefaction did not supervene, thus confuting Gay-Lussac's doctrine utterly. This was confirmed by Schwann (1839), Ure (1840) and Helmholtz (1843).

In the same year in which Caignard de la Tour made his discovery and Schulze confuted Gay-Lussac's doctrine, Donne (1836) noticed micro-organisms in pus and also in chancrous pus—the latter different from the former and causing its virulence. In the following year Beauperthuis and Adet de Roseville noticed the latter organisms and declared them to be the cause of putrefaction, in the next year (1838).

In 1837 Schwann of Berlin published the results of a remarkable series of experiments in the phenomena of putrefaction, proving them due to organisms and not to the oxygen of the air. His experiments proved that meat and other albumenoids became decomposed by the germs resident in the atmosphere; he clearly established the connection between putrefaction and microscopic life, but thirty years elapsed before Lister extended to wounds and living flesh the results of the researches of Schwann upon dead flesh and animal infusions. Prior to Lister himself the possibility of some such extension of the principles had occurred to other minds, such as Beauperthuis and Adet de Roseville. Penetrative, thoughtful minds had appreciated the fact that the germs which could cause putrefaction of meat and dead flesh might also act with fatal effect upon the living flesh in the hospital or sick room. Although the views of Caignard de la Tour, Schwann and Schulze

were tested and confirmed by many learned investigators, such as Ure and Helmholtz, they did not receive the attention due them, they obtained no general recognition but remained the property of a few skilled experimenters. It was admitted that the fermentation of sugar was due to the torulæ but it was not admitted that putrefaction was due to precisely analogous agencies, yet the two processes present more than merely striking parallels.

In 1841 Dujardin, who had devoted considerable attention to the subject, classed bacteria among the infusoria. In 1843 Helmholtz confirmed the doctrines of Schwann and Schulze.

In 1849 Pollender declared that he had observed organisms in the blood of animals that had died of splenic fever (anthrax).

In 1850 two distinguished French observers, M. Davainne and M. Rayer, noticed small organisms like transparent rods in the blood of animals dying with splenic fever. They, at that time, however, attached no especial importance to the discovery of this fact. Eleven years later Pasteur published his masterly memoir on the fermentation of butyric acid and described the organism which provoked and caused such fermentation; after reading this memoir Davainne came to the conclusion that splenic fever might also be caused by a fermentation or putrefaction set up and provoked by the germs which he and Rayer had observed in 1850. This idea has been placed beyond the pale of a peradventure by subsequent researches.

Up to the year 1850 the existence of micro-organisms had been confirmed by the investigations of many scientists, but the spores or germinal elements of the microbean cells were first observed by Perty in 1852 and by Robin in 1853.

In the year 1854 a very simple but important discovery was made by Schroeder and Von Dusch; this was the discovery of the fact that a plug of cotton wool or raw cotton placed in the mouth of test tubes would preserve even nutrient media contained therein from infection and consequent putrefaction. Simple as this discovery was, it has been of great service in practical and laboratory work in bacteriology.

In 1856 Panum demonstrated that inflammation of the intestinal tract of animals poisoned by decomposing matter was due to a chemical substance which was not destroyed by heat. This was probably one of the first observations of any value made as to the detrimental action of the products of germ excrementition or elaboration. Somewhat later Schmiedeberg and Bergmann isolated from fecal matter a crystalline substace which they called sepsin. They determined that when this substance was introduced into bodies it caused symptoms which were peculiarly analogous to those of the condition known as septicemia. As interesting and important as were these observations of Panum, Schmiedeberg and Bergmann they were practically devoid of any influence whatever upon current medical practice.

In the period from 1857 to 1861 Polli of Milan made extensive observations upon the power of sulphurous

acid and the sulphites in arresting fermentative and putrefactive processes. As a result of his numerous experiments and observations he initiated and formulated a plan for their use and administration in certain diseases which he thought caused by such conditions, that is, in zymotic diseases. In this same period Calvert had demonstrated that carbolic or phenic acid, which was always present in coal tar, was a powerful disinfectant and that it had been used in Manchester in 1857 for the preservation of dead bodies.

In 1859 M.Davainne attempted a new classification of micro-organisms, placing them in the vegetable kingdom.

In 1860 Pasteur demonstrated that a temperature of 110°–112°C. (the boiling point of water being 100°C.) was sufficient to completely sterilize. In the next year (1861) he published his memoir upon butyric fermentation and the organism provoking it—it was this essay that convinced Davainne (1863) that the organisms which, in 1850, he and Rayer had observed in the blood of animals infected with splenic fever (anthrax) were the cause of the disease and he so announced his belief.

Since the time of the discovery of the yeast plant by Caignard de la Tour the question of the origin of such organisms had been one which had given rise to continuous discussion and investigation on the part of a few. In 1862 Pasteur published a memoir in the *Annales de Chimie* which marked the inauguration of a new epoch; to the continuation of the investigations therein first set forth he has devoted the whole of the remainder of his

life. His solutions of the secrets of vinous, acetic and butyric fermentations unlocked the secrets of putrefactive fermentation—a discovery whose inestimable value we can only duly appreciate when we consider the woes which these wafted particles of microscopic life have caused in ages both historic and prehistoric. Compared with this record the mortalities of the world's battlefields pale into insignificance itself.

In this same year (1862) Dr. William Budd drew up a series of suggestions for the investigation of epidemic and epizootic diseases. To this he adds: "What we most want to know in regard to this whole group of diseases is where, and how, the *specific* poisons which cause them *breed* and *multiply*." There cannot be the slightest doubt, after perusal of this passage, that Dr. Budd had what might be considered—even at this day—a good modern conception of the subject, for his ominous words are in no sense ambiguous.

In the next year (1863) Lemaire, stimulated by Calvert's investigations into the antiseptic properties of carbolic acid and by numerous similar facts which had been laid before the Committee of the French Academy studied the subject diligently. The results he embodied in his memoir "De l'acide phenique," published in 1863. In this essay he recognized the germ theory of disease as the actual basis of antiseptic surgery and was one of the first to recognize its extensive use in the treatment of wounds. He extended the already existing belief in the preservative properties of carbolic acid and coal tar—for the Egyptians themselves used pyroligneous acid,

creosote and analogous compounds for these very purposes in the preparation of their mummies.

These, the first six decades of the present century, mark an important era in the development and growth of the belief and practice which was to pervade the latter decades of the century, much to its enlightenment and much to the value of the science of medicine whose prophylactic functions at least are thereby greatly widened. Among the many men of note in the period, among even so many worthy investigators Pasteur, as yet, stands head and shoulder above them all. Although the views of de la Tour, of Schwann and of Schulze were confirmed by several trustworthy investigators yet they made no marked impression, remaining the property solely of a few skilled investigators. It was Pasteur who first conclusively convinced the scientific world. Because of his precision and accuracy his experiments remain, even to day, unimpugned and above reproach. Pasteur's observations first resulted in facts of value—especially from a surgical and medical stand point. The practical application has saved the vineyards of France from the dreaded depredations of phylloxera and has prevented and eradicated many parasitic diseases of both plant and animal life. But most of all they enabled Lister to formulate his immortal system of antiseptic surgery which has saved many useful lives. He first claimed that the processes of fermentation, decomposition, suppuration and the occurrence of contagious diseases were all due to the presence of micro-organisms—which principle he called *contagium*

animatum. He also claimed that the processes which were due to the access, proliferation and multiplication of germs might be prevented by securing non-access of such germs.

He was not the first nor was he the only one to observe the facts embodied in his *contagium animatum* or infection by an organism, for the belief in its rudimentary state can be traced back to the year 1700 when the question was warmly discussed under the subject of spontaneous generation. Nevertheless his work, his investigations, his discoveries prepared and paved the way for the deductions of Lister who himself acknowledges his indebtedness to Pasteur and his researches.

In 1864 Spencer Wells, before the British Medical Association, pointed out the fact that the recent experiments of Pasteur had "all a very important bearing upon the development of purulent inflammation and the whole class of diseases most fatal in hospitals and other overcrowded places." He said further: "Their influence (germs) on the propagation of epidemic and contagious diseases has yet to be made out." Strange to say, though he recognized and admitted the effect and power of the organisms, he introduced no systematic method of combating them or of eliminating their injurious effects and yet in his own particular and peculiar sphere of practice has antiseptic surgery been most conspicuous and complete in its triumph.

As we observe, the time is now ripe, medical theory and practice is ready to receive the truths of a new and doughty champion whose work prior to this time

would doubtless have fallen upon sterile and unfruitful soil. The time has come when the efforts are to be crystallized, or the blossom to merge into the tangible fruit. Only at this particular time would his advent have been successful and at the precise moment of the need of his trenchant blade Joseph Lister steps into the scientific arena.

IV.—History.

From the Advent of Lister to the Present Time.

In the fullness of time appeared the man for whose coming the fates seemed to have conspired together. Neither too late nor too early did he appear, but when scientific discoveries had prepared the way and had made the minds of men ready to receive and profit by the observations which he had made and the conclusions which he had drawn from his observations. That the seed fell on good soil and flourished the splendid achievements of modern medicine, surgery and obstetrics fully attest. What medical science would have been without these grand generalizations and their subsequent results is shown by the condition in the era immediately preceding their enunciation and demonstration. To-day the

HOSPITAL IN THE FRENCH THEATRE.

germ theory of disease is the very foundation upon which the magnificent superstructure of modern medicine rests—ay, we might almost say that it is at once the foundation and the structure.

In the London *Lancet* of July 27, 1867, appeared an article by Dr. Joseph Lister entitled "A new method of treatment of Hernia in the presence of Atmospheric Air." This was the first step taken by him in the direction which was to ultimately yield him so many honors, so many laurels, so many brilliant results in the saving of human life in its battle with disease. Here was the germ of the acorn which was to spring into such a mighty oak, bearing healing in its leaves. In September of the same year another article by Lister appeared in the *Lancet* entitled "On the antiseptic principle in the practice of Surgery." This marks the date of the birth of the true antiseptic era—indeed it is the first use of the term antiseptic, being used in the sense of opposed to putrefaction. Lister's views in regard to the essentials of antiseptic wound treatment at this stage in the development of the practice may best be imparted in his own words:

"Decompositions in a wound and affections of wounds due to decomposition, are intimately connected with micro-organisms coming from without.

The wound treatment and dressing should prevent the access of micro-organisms, and, when these have entered notwithstanding every care, they should kill them or render them incapable of harm.

The dressing and the substances used for killing the

micro-organisms should not irritate the wound at all, or, at best, very little."

Lister's system of treatment consisted essentially in the exclusion of such micro-organisms as might possibly by their presence induce fermentative changes; or if, in spite of such precautions, such have gained access, to remove, or destroy them or at least render them innocuous. Such ends, he said, were to be attained by the use of certain germicidal substances. In this way pyemia, septicemia and erysipelas, once the scourges of surgical hospitals have, within a short period, become diseases of rarer occurrence than formerly. His favorite antiseptic was carbolic acid dissolved in various menstrua or impregnated in gauze, cotton wool or other surgical dressings. He claimed that if the treatment was thoroughly carried out the result would be no pain, no fever, no pus, no bacteria, no putrid smell, no septic infection and progress uninterrupted by any septic process. His claims in this respect seem to be almost fully borne out by the results achieved, for many operations are now safely and fearlessly performed which were formerly very formidable and fraught with considerable danger; such were the operations upon joints, bones, the peritoneum and other serous membranes. Then too in many cases where amputation was formerly and correctly (under the circumstances) deemed absolutely necessary the limb has been saved by the use of antiseptic methods; before the introduction of antiseptic methods the mortality following major operations was very high—in the period of 1864–1866 statistics place it at forty-five per cent (45%).

In the period immediately following the introduction of the antiseptic method (still in its infancy, still crude and undeveloped) the rate dropped marvelously to the low figure of fifteen per cent (15%)—which meant that thirty more lives out of every hundred were saved by this method that would have been sacrificed by the use of the methods in vogue in surgery before the introduction of the antiseptic method. In the period of 1871–1877, after Lister had somewhat modified his method, the rate dropped to twelve per cent (12%)! This was one of the greatest triumphs which modern medicine has ever witnessed,—indeed its effect should not for a moment be underestimated. Volkmann, the renowned surgeon of Halle, was about to close his wards on account of the prevalence and virulence of pyemia and septicemia; as a last resort he tried the methods of Lister and in the next five years the total mortality *did not exceed six per cent* (6%)!

That surgical "dirt" was fatal to success if not life itself in surgical operations had been noticed long before Lister's time, but few know the reason why. It was at this point that Lister sprang full panoplied into the scientific arena, coming forward with a theory or a scientific principle rather, which rendered it all very plain and rational. This surgical "dirt" then was fatal or infectious not because it was "dirt" but because it contained, as Schwann first proved, living germs which were themselves the direct causes of putrefaction and decomposition. In the year 1837 Schwann clearly demonstrated and established the connection between putre-

faction and microscopic life, that one followed from the other, that they were coincident and coexistent. But thirty years elapsed before Lister extended to wounds and *living* flesh the results of the researches of Schwann upon *dead* flesh and animal infusions. Prior to Lister himself the possibility of some such extension of principles had occurred to others—indeed Hueter had distinctly said twenty-five years before "no germ, no pus." Lister discovered no great scientific fact, yet he more than any one man created antiseptic medicine. To him pre-eminently belongs the honor and glory of extending the generalization of Schwann from dead to living matter; but by this apparently simple step he at once revolutionized the whole art and practice of surgery—indeed, now it became in truth a science. It was he too who first formulated a systematic method by means of which to fight these microscopic enemies of life and health. But his researches dealt with and applied to decomposition and putrefaction and conditions dependent upon them. It remained for Koch to further extend the generalizations, it remained for Koch to discover the existence of specific pathogenic germs, that each one of the infectious or zymotic diseases was caused by its own and peculiar germ. It was sufficient glory for Lister to have laid the foundation and he was magnanimous enough to acknowledge the aid which he had received from Pasteur in this great work (See *Etudes sur la Biere*—Pasteur, page 43)—indeed he expressly thanks Pasteur for having given to him the only principle which could have conducted the antiseptic systme

of treatment to a successful issue. To these three—Lister, Pasteur and Koch—the founders of the triumphs of modern medicine, be all the glory.

In the year 1870 Lister presented to the medical world his method of surgical dressing; this is now discarded even by himself, but the principles upon which it was based remain true to this day.

In the year 1873 Obermeier announced his discovery of the specific germ of relapsing fever. This the discoverer named, after himself, the "Spirochete Obermeieri."

In 1876 Cohn and Koch devoted considerable time to an investigation of spores—the peculiar reproductive bodies of some forms of germ life. Until this time comparatively little attention had been paid to them, through ignorance of their importance.

In the next year Koch announced his discovery of the fact that the terrible disease anthrax was due to a peculier and specific germ which he had succeeded in isolating. In this same year Weigert introduced his method of staining germs in order to make them plainly visible in the microscopic field and thus to facilitate observation of their habits, peculiarities, etc.

In the year 1878 Koch, who was becoming exceedingly prominent in the field of bacteriology, published his important work on traumatic infectious diseases.

In the next year Hansen announced his discovery of the specific bacillus of leprous tubercles. In the same year Neisser discovered the gonococcus, supposed to be the specific cause of gonorrhea.

In 1880 Laveran successfully demonstrated the relation of the "plasmodium malariæ" to the etiology of malarial disease. In this same year Eberth and Koch made their discoveries of the specific germ which caused typhoid fever. Sternberg and Pasteur also made important researches into the nature and origin of pneumonia and discovered its diplococcus. But the most important work and discovery of the year was Koch's announcement of his experiments and belief in the efficacy of protective inoculations of attenuated cultures of germs. Thus he points a way for the medicine of the fnture. Indeed the important work of the past few years has been mainly in this direction—its legitimate outcome was the tuberculin of Koch, the anti-cholerine of Klebs, etc.

In the next year Koch called attention to what he considered the greater potency of mercuric chloride as an antiseptic; this he recommended in the strength of 1:1,000. In the same year he made important researches on the resistive powers of anthrax spores to heat. He also introduced the use of solid culture media and the plate method for pure cultures.

In 1882 Schutz and Loffler announced their discovery of the bacillus of glanders and Pasteur issued his first communication on the subject of rabies—a field of work in which he has so justly become famous. But the greatest work of all was to come in the demonstration of the cause of tuberculosis. This was accomplished by Robert Koch. In the month of March, 1882, he read a paper on the subject before the Berlin Congress; so

complete and thorough was his work and so convincing were his conclusions and proofs that no one left that hall unconvinced that the true cause of that dread disease which carries off more than war and famine combined had at last been discovered. This did not necessarily mean its cure, but it was a vast stride in that direction. And this work he achieved in the face of what were thought to be insurmountable obstacles.

In the next year the British Government, recognizing the service which Lister had rendered humanity, knighted him, bestowing upon him the title of Baronet.

In 1884 Gaffky made important researches upon the bacillus of typhoid fever. In this same year Nicolaier discovered the bacillus of tetanus, Loffler the bacillus of diphtheria and Koch the cholera spirillum or "comma bacillus." In the next half-dozen years comparatively little was accomplished.

In 1890 Baumgarten made a new classification of micro-organisms.

In 1892 Pfeiffer and Canon independently discovered the specific germ of influenza, the bacillus influenzæ.

In 1893 Sir Joseph Lister, after twenty years of experiment and research renewed his allegiance to carbolic acid as the antiseptic *par excellence.* He announced that carbolic acid is not only a more efficient germicide than corrosive sublimate (that is, mercuric chloride which had previously been the favorite antiseptic, despite its poisonous nature in even comparatively small amounts) but that it is much more efficient in cleansing the skin. Also that it has a powerful affinity for the

epidermis, penetrating deeply into its substance and mingling with fatty matters in any proportion. Whereas corrosive sublimate cannot penetrate greasy substances in the slightest degree, hence when used it requires elaborate preparation of the field of operation in the way of scrubbing and cleansing the skin. In accordance with these the latest conclusions of the pioneer in the field of antiseptic surgery, American enterpise has met the emergency by putting into the surgeon's armentarium a new antiseptic composed of carbolic acid and boracic acid; this product has been very fittingly named Senn·ine after one who has done so much for American surgery.

As Dr. Pepper recently said in his presidential address to the Pan-American Medical Congress: "Every one now knows, *or ought to know*, that disease is due in a vast majority of instances to micro-organisms which live, flourish and die subject to certain and peculiar laws." So that it almost seems like folly in these closing years of the nineteenth century to insist upon the truth of the germ theory of disease; it is a part of the history of the medical progress of the century and there are, indeed, none so blind as those who will not see.

Research has undoubtedly established and demonstrated a distinct and direct relation between certain forms of infectious diseases and their specific micro-organisms. All authorities and investigators agree that, whether these organisms are the virtual causes or but concomitants, the processes and phenomena attendant upon their invasion, development and decay within the

tissues give rise to the elaboration of substances as deadly as the most toxic of drugs. These substances, called ptomaines, leucomaines, etc., are chiefly the result of the processes of excrementition and elimination which are naturally coincident with the life history of the germ and unless neutralized, destroyed or eliminated in some manner are as fatal to life or health as the most powerful of toxic agents. It is now definitely known that the alarming symptoms of many of the infectious diseases are due more to the presence of these products rather than to the presence of the germ *per se.* As in tetanus, the germ may be localized in its action but its excrementitious products, may be absorbed and carried through the avenues of the vessels to all parts of the system and thus from many points of attack completely overwhelm it.

But the presence of germs is not necessarily destructive to the life of the human organism. In health the pathogenic germ does not find sustenance and can not thrive in the normal and healthy secretions of the body and when such germs invade the system they are destroyed by certain of the white blood corpuscles by means of the process of phagocytosis. But when the organism becomes debilitated and disordered the omnipresent germs find sustenance in its depraved secretions and thrive and multiply there until they completely overwhelm and destroy it. When health, the great and universal antiseptic, is impaired in its virtues then Nature must of necessity lean and depend upon Art.

V.—The Products of Vital Cellular and Bacterial Activity.

The time has long past when the doctrine of the micro-organic origin of disease and infection was forced to contest its claims to recognition and acceptance. It stands to-day in the position of a demonstrated and generally accepted fact. Indeed the purely deductive argument advanced as to the causation of infectious diseases by living organisms has been staunchly supported during the past twenty-five years by a mass of reliable observations and experiments which render the doctrine no longer an hypothesis, or a theory, but a clearly demonstrated and established fact. Upon such a strong foundation of fact the argument by analogy possesses added force in support of the micro-organic origin of those infectious diseases in which the specific organisms have not as yet been either discovered or isolated. The proof becomes complete and absolute when three conditions are fulfilled; these are first, the demonstration of the constant presence of a special or specific germ in association with the lesions and symptoms of the disease; second, the isolation and cultivation of this specific organism by means of a series of pure cultures; third, the production or generation of the disease in an organism free from it by means of the inoculation of the organism so isolated. The presence of all three conditions is sufficient proof, indeed most convincing proof.

SURGICAL CLINIC—PROF. NICHOLAS SENN.

Not only has the micro-organic origin of putrefaction and fermentation been settled beyond any possible shadow of doubt but the same principles have been more widely applied in their relations to the cause of disease in general. For this generalization and extension of principles we are indebted to the illustrious Koch. To Schwann we are indebted for the demonstration of the dependence of putrefaction in *dead* flesh upon micro organisms; to Pasteur and to Lister for the extension of these principles to *living* flesh; but to Koch for the extension of the principle to the specific causes of various infectious diseases.

All living cells, whether of animal or vegetable origin, while in the conditions of active growth and development appropriate for their nutrition, by processes of selection it may be, certain desirable elements from among those which constitute the food with which they are supplied. At the same time they also excrete various substances which, in some cases at least, it may be their special and peculiar function ty produce. In the case of members of the higher orders of the animal and vegetable kingdoms these functions of secretion and excretion may be delegated to special cells whose peculiar function may be the elimination of substances injurious to the economy or to the secretion of substances necessary its existence. For example, among the higher animals we have the special function of the excretion of urea delegated to the epithelial structure of the kidneys, while to the mucous membrane of the stomach with its gastric glands are delegated the functions of gastric

secretion so necessary to the material existence of the organism. The functions of which these are a type may be found in a simpler and possibly more modified degree in even the lower members of both kingdoms, all of which functions seem to serve, either directly or indirectly, the promotion and preservation of the health of the organism. Even the deadly ptomaines, so prejudicial to the health and life of the unwilling host of the pathogenic bacteria, subserve the interest of the germ by paralyzing the vitality and resistive power of the organism upon which, and at the expense of which, it thrives.

It was generally believed, until quite recently, that air and its contained oxygen were absolutely necessary to all forms of animal life. The life of a more or less complex organism is necessarily the sum total of the lives of its various component parts which are, in the main, animal cells. Gautier has successfully proven that at least one-fifth of these are anaerobic; that is, the generation of the vital force is not in these special forms dependent upon the presence of air. But whether dependent or not all cells excrete cetain products which must of necessity be expelled from the organism or else its vitality must succumb. Were the carbon di-oxid, the urea, the water or even the heat generated in the vital processes of the human organism allowed to accumulate either one could and would eventually destroy the very vitality which brought it into existence.

Indeed the products of vital activity on the part of the germ or cell are exceedingly numerous and varied.

A considerable number of species possess the peculiar power of forming certain pigments of various shades and colors which may run the whole chromatic gamut of the solar spectrum from the violet on the one side to the red on the other. This fact is made use of in the classification and nomenclature of certain micro-organisms. Again, certain species have the power, when placed in a culture medium of gelatin, of liquefying the gelatine in their immediate vicinity; while others may thrive and multiply abundantly in the same medium without the production of such phenomena. Indeed this fact, as was first shown by Koch, is an important one in the differentiation of many species resembling each other in many respects. More over certain bacteria have the property of causing the development of an acid reaction in the media in which they are cultivated. This power may well be shown by adding litmus infusion to neutral or alkaline culture media. The change in color from blue to red, due to the formation of an acid, may be followed macroscopic ally by the naked eye. Among the acids which may be so produced are formic, acetic, butyric, propionic, valeric and many others of the group of so called "fatty acids," as well as others. Then also the putrefactive decompo sition of proteid bodies may be effected by a great variety of micro-organisms, giving rise to as great a variety of products, some of which are gaseous, ephemeral and exceedingly malodorous. Of course such products of putrefaction vary with the nature and composition of the body decomposed, the conditions by which

it is surrounded and by the micro-organisms present affecting such decomposition.

But probably the most important of all the substances resulting from germ life which can engage our consideration are those which have been variously termed ptomaines, leucomaines, toxines, toxalbumins, animal alkaloids, putrefactive alkaloids, bacterial proteids, etc. The fact must have been known even to primitive man that the ingestion of putrid flesh was liable to affect the health to an extent more or less serious in nature. Consequently he must then have made some attempts at preservation, however crude; these may or may not have been successful, in the latter case giving rise to an increase in and multiplication of cases of poisoning from putrefactive products. These facts must have resolved themselves into questions of prime importance very early in the history of the race, for coeval with our first periods of history we find definite records which show that man was, even at that remote time, busily engaged in his serious battle against the ravages of time, decomposition and decay. Though the facts themselves were known and the causes but dimly dreamed, no attention was paid to the consideration of the products of decay themselves until the eighteenth century. Since then chemists have at various times isolated from putrefactive products, or from cultures of the bacteria concerned in putrefaction, or from certain other pathogenic species, various nitrogenous substances resulting from the action of bacteria upon organic substances; these were basic in character and strongly re-

sembled in nature and in chemical constitution, as well as physiological action, the so-called vegetable alkaloids—indeed they have been variously termed animal and putrefactive alkaloids.

It is hardly possible even in the present advanced status of science to closely follow up all of the various chemical changes which complex bistologic molecules may undergo, yet it is hardly sufficient to say that a ptomaine is the alkaloidal waste product of the cell. It is in reality something more than this, representing as it does the result of a series of cyclical changes which in themselves represent the tremendous cellular activity by means of which they were engendered. However the essential idea is that of putrefactive change; while leucomaines are supposed to be those vital and essential and analogous alkaloids which are formed in the *living* organism and prior to its death. Some of these substances are non-toxic while others, graphically termed *toxines* by Brieger, are extremely poisonous, even in minute doses. While some of them may be non-toxic however, yet their continual retention, accumulation and consequent absorption may result in serious harm, al though not the direct result of active toxicity. Indeed the products of life are largely excrementitious in character and cannot be retained within the organism for any appreciable length of time with impunity. Normally they undergo destruction or excretion by those ordinary physiological processes which are, in perfect health, in constant operation. If from any cause these processes are interrupted, whether that cause be emo-

tional or physical, defective absorption, oxidation or excretion results and the blood becomes charged with abnormal products; these are carried to the centres of life and function and the result is the institution of one or more of the various protean forms of disorder. With each and every micro organism the function of excretion is obligatory—indeed it is but a link in the completed chain of vital activity. Ptomaines and leucomaines are the result, the first in the dead body and the second in the living body; they are residual products just as much as the carbon di-oxid and urea of the human organism. When these residual products of micro-organic life are once generated within the system the tissues seem incapable of selection, making no distinction either as to origin or intended destination.

The term ptomaine (a cadaver or that which has fallen) was first suggested by the Italian toxicologist Selmi as a suitable name for certain cadaveric alkaloids which he had isolated. Although the effect of the ingestion of putrid matter upon man and the lower animals must have been observed ages ago, yet Albert von Haller, the distinguished physiologist, seems to have been the first person to institute systematic and scientific experiments with a view to a more exact knowledge of the phenomena involved. He injected aqueous extracts of putrid matter into the veins of animals and found that death followed. Later in the eighteenth century Morand gave an account of symptoms induced by the eating of poisonous meat. Very little other research was indulged in until the present century. Gas-

pard (1806—1813) carried on experiments similar to those of Haller and Morand; he produced nervous disturbances, stiffness of the limbs, opisthotonos and tetanus. He thought the untoward symptoms were not due to carbon di-oxid or hydrogen sulphid, as had been suggested, but admitted the possibility that ammonia might play some part in the production of such symptoms. When we remember that most of the ptomaines are either amines or analogous compounds and that the first determination of their exact chemical nature was made by Nencki in 1876 we can hardly restrain our admiration of the accuracy of this surmise of Gaspard which anticipated in a measure the results revealed by chemical science sixty-five years later. Kerner (1820) published his first essay upon poisonous sausage, followed by a second in 1822. He at first thought the poisonous principle to be due to the presence of a fatty acid (which he termed caseic acid) generated in the putrefactive process; later he thought it was a compound resulting from the union of the fatty acid and a volatile principle. Thus Gaspard and Kerner clearly hint at the basic character of the poisonous principle of decomposition. Dupre (1822) observed and reported the existence of a peculiar diseese which existed among the soldiers of a garrison compelled to drink very foul water during a warm and dry summer. Magendie, Leuret, Dupuy and Trousseau carried on investigations but contributed comparatively little to the knowledge of the subject, Dann, Weiss, Buechner, Schumann, Cadet de Gassicourt and Orfila all devoted

considerable study to the active principle of poisonous sausage but made no advance upon Kerner's original work. Henneman, Huennefeld, Westrumb and Sertuerner investigated the principle of poisonous cheese; this however they believed to be the caseic acid of Kerner. Schmidt of Dorpat (1850) made researches into the nature of the decomposition products and volatile substances found in cholera stools. Meyer (1852) studied the effects produced by the injection of the blood and stools of cholera patients into the lower animals. Stich (1853) discovered that putrid matter in sufficient quantities produced intestinal catarrh and choleraic stools when ingested. These were accompanied by nervous tremblings and other symptoms together with an unsteady gait, but produced no lesions. He concluded from these results that putrid matter must contain a ferment capable of producing rapid decomposition of the blood.

Panum (1856) made a most important contribution to the subject. He demonstrated positively the *chemical* nature of the posionous principle of putrefaction and showed that the aqueous extract of putrid material retained its poisonous properties even after heating and such treatment as would insure the destruction of organisms if present. The results thus obtained were confirmed in the next ten years by Weber, Hemmer and Schwenninger. Bence Jones and Dupre (1866) obtained a similar body from liver. Bergmann and Schmiedeberg (1868) separated a poisonous substance, which they called sepsine, from putrid yeast and decomposing

blood. Even when administered in small doses this substance produced vomiting and profuse bloody diarrhea in dogs and, in sufficient doses, death. Zuelzer and Sonnenschein (1869) prepared a nitrogenous base from decomposing meat. In its chemical reactions and physiological behavior it strongly resembled atropin and hyoscyamin; it was also found in the bodies of those dead from typhoid fever and it was thought possible that the belladdonna-like delirium of the latter stages of the disease might be caused by an ante-mortem generation of the poison within the body. Though many efforts had been made to isolate as well as to produce these peculiar substances such isolation was first successfully accomplished by Francesco Selmi (1873–1876). He made extensive and valuable researches, it is true, but remained in ignorance of the chemical constitution and composition of the bodies which he had isolated. Indeed Nencki (1876) made the first ultimate chemical analysis and determined the first chemical formula for a ptomaine; this was an isomer of collodine. Roersch and Fassbender obtained in a case of suspected poisoning a liquid which could be extracted by ether from either acid or alkaline solutions; it gave all of the characteristic alkaloidal reactions, resembling digitalin in particular. Gunning found the same alkaloid in liver-sausage, from which poisoning had occurred. From human bodies which had been dead for several months Selmi removed many alkaloidal bases; one was found to be a very violent poison, producing in rabbits tetanus, marked dilatation of the pupils, paralysis and

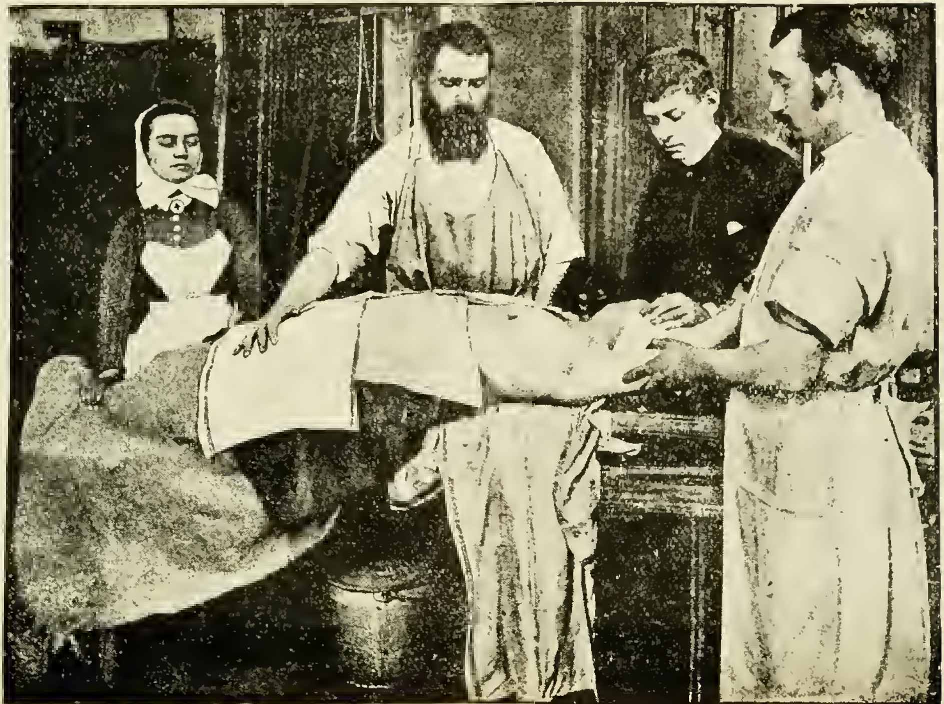
death. Lombroso (1871) showed that the extract from mouldy corn meal produced tetanic convulsions in animals. These investigations threw some light upon the causes of sporadic cases of illness among the peasants of Lombardy who eat fermenting and mouldy corn meal. In 1876 Brugnatelli and Zenoni obtained an alkaloidal substance from this mouldy meal. Guareschi and Mosso obtained various volatile and non-volatile bases from decomposing human brains. Brieger of Berlin isolated and determined the composition of a number of ptomaines and in 1885 published a valuable work upon the subject. From pure cultures of the typhoid bacillus of Eberth and Koch he obtained a poison (typhotoxine) and from similar cultures of the tetanus germ of Rosenbach he produced a similar body (tetanine). Brieger calls special attention to the fact that most of the characteristic ptomaines are diamines; that chemically they are more simple in composition than the vegetable alkaloids, which they resemble, and that many of the ptomaines are derivatives of hydro-carbons of the ethylene series and are in distinction from true alkaloids representing the pyridine group. Vaughan, who is by far the leading American authority upon the subject of ptomoines, isolated in 1884–1885 an active agent (tyrotoxican) from poisonous cheese. Koch and others demonstrated the presence of a poisonous substance in cultures of the cholera bacillus; Hoffa did the same in the case of the anthrax bacillus. Hankin (1889) isolated a toxic albumose from cultures of the anthrax bacillus which proved fatal in quanties *but in small doses af-*

forded immunity. The investigations of the past few years have been mainly in the direction indicated by the results of Hankin. Now the fact that a germ is pathogenic is considered to be sufficient evidence of the fact that it elaborates poisonous products and the study of these products is justly regarded as one of the greatest importance in the investigation of the germ and the disease which it causes. The interest in the subject is not confined alone to the study of the aetiology of disease but strenuous efforts are being made with a view towards the securing of immunity from disease and indeed even to effect cures of disease by means of the use of these self-same bacterial products. If the excrementitious products of the human organism possess the power, when retained, of ultimately destroying the life or impairing the health of that organism, why should not such be true also of the germ which likewise generates excrementitious products? Our knowledge of the latter conditions is as yet in the embryonic stage, but to that knowledge, crude and imperfect as it is, we owe the tuberculin of Koch, the anti-cholerine of Klebs, the pneumotoxine, typhotoxine, etc., which though not as successful and infallible as enthusiasm had anticipated, yet in spite of their crudities and imperfections, succeeded in making a vast and manifest stride in the proper direction; when they failed they taught lessons as valuable as those imparted by their successes. In this direction lies the domain of the medicine of the future; in this direction Science points with inexorable finger. Who can predicate the successes of the future which

lie as yet unborn within the matrix of Eternity?

Indeed we may now regard it as conclusively proven that the pathogenic power of those bacteria instrumental in the development of so many and various infectious diseases in man and the lower of animals is largely if not entirely dependent upon their power of producing toxic ptomaines or toxalbumins. They may affect the organism directly or indirectly by the medium of the food or ingested articles. That is, the toxic substances may be produced within the body by septic or other processes and then after absorption give rise to systemic infection. Or the products may be elaborated in such articles as cheese, milk meat, etc., and the toxic products resulting from an extraneous action may upon ingestion give rise to symptoms strongly resembling in their dangerous and alarming nature the characteristics of acute alkaloidal poisoning.

The field of research in the direction of the therapeutic applications and value of the products of vital bacterial activity lies almost fallow. Its primitive cultivation has afforded such rich fruit that we are justified in looking to it for an abundant harvest. When Science shall have placed within the hands of the physician those potent weapons which the germ itself uses with such deadly effect, then shall begin such a battle with disease as the world has never witnessed and then shall ensue a victory which shall be not more glorious than complete.



ANTISEPTIC ARRANGEMENTS BEFORE AMPUTATION OF BREASTS.

VI.—Infection, Susceptibility and Immunity.

The human organism is exposed to infection of various kinds at every point. The infection of open and exposed wounds is, or rather was, a thing of daily occurrence; thanks however to the principles of antiseptic and aseptic surgery the occurrence or formation of pus at the present day is comparatively rare under proper treatment and is really nothing more nor less than an evidence of the ignorance or carelessness of the physician or surgeon in charge Schimmelbusch has definitely proven in his experiments with the *Staphylococcus pyogenes aureus*, *Bacillus authracis* and other micro-organisms that infection is undoubtedly possible through the channel of the unbroken skin. Machnoff in his experiments with the effects of the *Bacillus anthracis* upon guinea pigs came to the same conclusion. Indeed these results have been further confirmed by the results obtained by Roth, Braunschweig, Ribbert and others.

Buechner instituted researches for the purpose of determining the possibility of infection through the channel of the intestinal mucous membrane. For this purpose he used mice and guinea pigs and fed them upon anthrax spores. In four cases out of thirty-three positive results were obtained, that is, the disease developed. This definitely proves that while infection does not necessarily follow the ingestion of infected material, it is nevertheless posible. Indeed it is more than ex-

ceedingly probably that this is the usual mode of infection in typhoid fever.

Buechner also made experiments with a view to testing the possibility of infection by means of the mucous membrane of the respiratory tract. In these experiments he obtained positive results in fifty cases out of sixty six, —showing that the chances of infection by the channel of mucous membrane of the respiratory tract are greater than in the case of the intestinal tract. The possibility of infection by the former channel is substantiated by the disease termed "wool sorter's disease"; here the infectious material set free by the handling of infected wool is inspired by the sorter, instituting the peculiar disease. Hildebrandt has experimentally demonstrated that under ordinary circumstances the majority of bacteria suspended in the air do not reach the lungs or even the trachea, but are usually deposited upon the mucous membrane of the mouth, nares or fauces; but that in prolonged respiration in an atmosphere so charged with bacteria, the micro organisms may be found deposited in the lungs. This may probably explain, in some degree, the relative frequency with which laryngeal or pharyngeal tuberculosis accompanies the pulmonary form of the disease, especially its more virulent forms.

In general however, we may say that man is most frequently attacked by the infectious diseases through the media of the alimentary canal, the circulatory or lymphatic systems and the respiratory tract. The gastric juice and the absorbent cells of the stomach and

intestinal tract afford physiological guards against infection by means of the alimentary canal; hence, susceptibility to the various infectious intestinal diseases must depend, to a certain extent, upon those causes which render the physiological guards defective. All germs which have the power of generating toxic substances are dangerous when introduced into the intestinal canal; this is dependent upon their capability of producing chemical poisons which are usually proteid in character and probably produce their objectionable actions by virtue of some process of catalysis. When the complex cellular molecules are split up, simpler ones are formed; but the chemical action implies the generation of a certain amount of heat and hence fever is the most common and predominant manifestation.

The physiological guards against infection through the channel of the blood or of the lymph lies in the germicidal powers of the proteids of these fluids and susceptibility to infection by such channels is, to a certain extent, dependent upon the impoverishment of the fluids. Hence the treatment of consumption and other similar diseases by means of liberal diet, constitutional remedies and plenty of exercise in the open air is founded upon a true and proper scientific basis and is not purely empirical in character.

It has long been known and observed that certain species are specially predisposed to certain diseases while other species enjoy more or less immunity to the same. Thus man is especially subject to attacks of such diseases as typhoid fever, relapsing fever, cholera and

others while the lower animals do not suffer at all with them. On the other hand man possesses immnnity to many of the infectious diseases of the lower animals. Immunity to disease may also be racial in character. For instance the negro is decidedly less subject to yellow fever than is the white man, but on the other hand he is especially susceptible to small pox. Then again, Algerian sheep are immune to anthrax, a disease which is markedly fatal among other sheep Immunity may also be individual in character; thus we have certain diseases, of an exanthematous type especially, to which adults seem more or less immune but to which children possess such a marked and peculiar susceptibility that such are freqnently termed "*children's* diseases."

The most essential, indeed *the* essential difference between a suceptible animal and an immune animal lies in the fact that in the one the pathogenic germ invades the tissues and multiples, producing certain changes in the tissues and fluids of the animal so infected which prove prejudicial to its life or health. In the immune animal on the other hand even though invasion is accomplished, multiplication does not usually occur, or if it does it is restricted to a circumscribed area in which the invader is ultimately destroyed by the operation of the natural processes. The question then resolves itself into this—in what consists this difference, or upon what does it depend? The question is a simple one, it is true, but its solution has been fraught with much labor. Upon what does this difference depend? Surely not upon the germ, for that is, as it were, a common factor

in each case, whether it be of susceptibility on the one hand or immunity on the other. It must then depend upon conditions of some kind surrounding the germ and which are either favorable or unfavorable to its development.

As early as the year 1881 Sternberg suggested that the leucocytes might pick up, assimilate and dispose of bacterial organisms. This suggestion was based upon the observation that leucocytes did take up inorganic granules, that bacteria had been found within their substance and also that amœbæ fed upon bacteria and similar organisms. 1884 Metschnikoff took the idea up and elaborated it, suggesting the name of phagocytosis for this so called function of leucocytes, which was based upon the idea that the phagocyte actually *ate up* the micro-organism which it took within its substance. Baumgarten, Weigert and others suggested that perhaps the bacteria observed within the substance of the leucocytes may have been already dead when picked up, having been destroyed *outside* of the white blood-corpuscle. Indeed we now have the conclusive experimental evidence of Buechner and others that blood-serum possesses considerable germicidal power *independent of its cellular constituents*.

It seems then that the cells of the animal body must be concerned in the production of this condition called immunity, this may be either the result of direct or indirect action; that is, either the cells may possess this power or they may contain or elaborate a substance vested with such powers. Immunity may be acquired

or natural. Among the best examples of the natural variety we might cite the case of the immunity of the common rat, the frog, the dog and the common domestic fowl to anthrax. The chick from the earliest period of its existence is naturally immune to even the most virulent cultures of the anthrax bacillus, as has been demonstrated by Lazarus and Weyl. True it is that a susceptibility may be induced artificially but this is practically but a *perversion* of natural properties. Racial immunity is supposed to be more or less due to an acquired tolerance due to processes of natural selection and inheritance. This, it is claimed by some, results naturally from an application of the law of the survival of the fittest as well as that of the law of heredity. In this view of the subject it is supposed that the feebler cells are killed or destroyed in the struggle for existence and that when recovery supervenes the body resumes its normal functional activity. But now it will contain the progeny of those cells which were originally strong enough to resist the effect of that particular disease through which it has passed. It is but natural to suppose that those parent cells have transmitted their qualities to to their offspring. Thus it is rather by a death of the weaker and less resistive cells than by an acquisition of new powers on the part of the surviving cells that immunity is afforded. The strong survive by virtue of their strength and this tends to perpetuate and improve the species. Certain it is that animals transmit their personal peculiarities to their progeny—and what is an animal but a collection of cells, the sum total of whose

vitalities forms the vitality of the animal? If this is true of a collection or aggregation of cells, may it not be also true of a single cell? It is certainly plausible to believe that properties already possessed by cells may be transmitted to their descendants, for the transmission of congenital traits seems established beyond a peradventure. Our conclusion then must be that immunity, where it exists racially, is due to inherent properties of the parent cell and their natural development with that of functional activity; also that these properties may be transmitted to their pregeny.

The natural immunity which is peculiar to the individual usually becomes more prominent or active with adolescence or adult life. Thus the young rat is susceptible to anthrax while the adult is immune and can only be rendered susceptible by reducing, in some manner, the vital strength or resistive power. Again, the child is highly susceptible to those peculiar diseases called "children's diseases," such as scarlatina, diphtheria and the acute exanthems; the adult, while not entirely immune, possesses little susceptibility. This seems to be in some way dependent upon a higher vital resistive power, for the adult does not usually contract the disease unless exposed to it for a long period or else reduced in vitality. As Vaughan says: "The only resonable explanation of this immunity is that it is inherent in the parent cell and comes as naturally as the changes in form and voice at puberty or as the growth of the beard in early manhood." If this be so then we may reasonably conclude that immunity is, in all prob-

ability, one of the phenomena inherent in the vital activity of certain cells.

Lewis and D. Cunningham, as early as 1872, showed that bacteria rapidly disappear when injected into the circulation.

In 1874 Traube and Gschiedlen demonstrated that when arterial blood, under antiseptic precautions, was taken from a rabbit, into whose jugular vein a fluid rich in putrefactive germs had been injected forty-eight hours previously, it failed to undergo decomposition for months. These germicidal properties they erroneously attributed to the "ozonized oxygen" of the blood.

Wyssokowicz had also noticed that bacteria rapidly disappeared from the circulation when injected therein; he stated that this was due to their deposition in the capillaries of the tissues.

Grohmann and Schmidt experimented with extravascular blood and found that anthrax bacilli which had been kept in plasma were modified in virulence; this they attributed to the process of coagulation.

Fodor (1887) combated the theory of Wyssokowicz that the disappearance of bacteria from the circulation was due to their deposition and retention in the capillaries. He proved that blood freshly drawn from the heart possesses consiberable germicidal power; that even when kept *without* the body, in blood in a pipette, the germs rapidly diminished in number. After awhile the blood seemed to lose its germicidal properties and there followed an increase in the number of germs.

In the next year Nuttall demonstrated the power of

defibrinated blood to destroy various pathogenic and non-pathogenic organisms. He also confirmed Fodor's conclusion that after a time blood loses its germicidal properties and then becomes an excellent culture medium.

Behring has shown that the blood of various animals differs in the intensity of germicidal powers—thus in some cases it was found to be decided in the case of certain pathogenic bacteria, less so for others and absolutely lacking in the case of certain common saprophytes. He demonstrated that the blood of the rat and frog, which possess special immunity to anthrax, is especially fatal to the anthrax bacillus. While this germicidal action is very prompt it is very limited and when the number of germs is excessive, development may follow an interval of limited destruction—thus it seems that the power is ultimately neutralized or exhausted after its exercise for a definite period. These results were somewhat similar to those of Fodor and Nuttall.

Buechner, Voit, Sittmann and Orthenberger made most exhaustive researches into the germicidal properties of blood and (1890) made a most valuable and important contribution to the subject. The work of these investigators is of such importance that a statement of the results of their work is justifiable; they may be tersely summed up as follows:

1. The germicidal action of blood is not due to phagocytes, because it is not influenced by the alternate freezing and thawing of the blood, by which the leucocytes of the rabbit are destroyed.

2. The germicidal properties of the cell-free serum must be due to its soluble constituents.

3. Neither neutralization of the serum,nor the addition of pepsin, nor the removal of carbon di oxide gas, nor treatment with oxygen has any effect upon the germicidal properties of the blood.

4. Dialysis of the serum against water destroys its activity, while dialysis against 0.75 per cent salt solution does not. In the diffusate there is no germicidal substance. The loss by dialysis with water must be due to the withdrawal of the inorganic salts of the serum.

5. The same is shown to be the case when the serum is diluted with water and when it is diluted with salt solution. In the former instance the germicidal action is destroyed, while in the latter it is not.

6. The inorganic salts have in and of themselves no germicidal action. They are active only in so far as they affect the normal properties of the albuminates of the serum. The germicidal properties of the serum reside in its albuminous constituents.

7. The difference in the effects of the active serum and that whicb has been heated to 55°C. is due to the altered condition of the albuminate. The difference may possibly be a chemical one (due to changes within the molecule) or it may be due to alterations in mycelial structure. The albuminous bodies act upon the bacteria only when the former are in active state.

Vaughan in commenting on these results says: "We wish at this point to call attention to an inconsistency between the results obtained by Buechner and the con-

clusion that he draws. In experiment No. 45 he renders the serum slightly acid and adds 0.1 gram of pepsin to each five c. c. of serum (showing by a side experiment that this pepsin actively digests coagulated egg albumin in neutral solution) and finds that the digestive action of the pepsin does not lessen the germicidal properties of the serum. In fact he states this in his conclusions, but his ultimate opinion, and the one held by him in his latest contribution, is that the germicidal constituent of the blood is the serum albumin. How much serum-albumin remains in blood serum after it has been thoroughly digested with pepsin? He could scarcely have chosen a more positive method of demonstrating that the germicidal constituent is not serum-albumin. Either his pepsin was not active, (Mr. Vaughan seems to forget that it was expressly stated that a control experiment demonstrated the activity of the pepsin in its ability to digest coagulated egg-albumin. However, this does not affect his argument or its truth in the slightest degree.) and on this supposition his experiment is without value, or the active constituent of blood-serum is a substance that is not destroyed or materially altered by peptic digestion. We know that the peptones not only have no germicidal properties, but that they belong to that class of proteids that is most favorable to the growth and development of germs. We recognize this fact when we add peptones to the various artificial media on which we cultivate germs." This objection of Vaughan's certainly appears to us to be well taken, nevertheless the fact remains that the results

announced by these observers are among the most important that have been made upon the subject. Indeed the success with which they met induced many others to enter this new field of research. The result is that although much useful information as to the germicidal powers of the blood under various conditions has been thereby elucidated yet as far as the exact nature of that germicidal constitutent is concerned but little or no progress was made—if we except the comparatively recent and masterly collaborations of Vaughan, Novy and McClintock. Behring and Nissen obtained results which seem to indicate that the action of blood within the natural channels and that of extra-vascular blood is vastly different. Pekelharing's experiments proved that the disappearence of anthrax spores, enclosed within parchment, when introduced beneath the skin of rabbits was not due to phagocytes but to some soluble poisonous substance. Halliburton separated a cell-globulin from lymphatic glands; Hankin found that this substance possesses marked germicidal proportics. Christmas also prepared a germicidal substance from the spleen and other organs.

Attempts have been made also to determine the exact nature of this germicidal constituent of the blood and tissues by the action of precipitating reagents upon the proteids of blood-serum. Buechner, Christmas, Bitter, Emmerich, Tsuboi, Steinmetz, Loew and others have given much attention to the subject.

Fodor and Zuntz had shown some time ago that freshly drawn blood decreases rapidly in alkalinity upon stand-

ing, just as it seems to lose in germicidal powers. Indeed Behring had suggested that the action of the blood of the white rat upon anthrax bacilli was due to its great alkalinity. Vaughan too has suggested that the blood of the adult rat, which is not susceptible to anthrax, is more alkaline than that of the young rat, which is susceptible to the disease. Emmerich and his coworkers demonstrated that blood-serum rendered faintly acid not only has no germicidal power but furnishes a good culture-medium. Behring demonstrated that the white rat lost his immunity to anthrax when the acid phosphate of calcium was mixed with its food in quantities sufficient to neutralize the alkalinity of the blood; Fodor also demonstrated that the resistance of rabbits to anthrax was markedly increased after the administration of sodium phosphate or of the alkaline carbonates. In 1887 he had noticed that after awhile infected blood lost its germicidal properties and became an excellent culture medium. May this not have been due to a loss of alkalinity, dependent upon the formation of acid products and subsequent neutralization of the natural alkalization? Certainly it is proven that bacterial activity may generate many and various acids, such as formic, acetic, butyric, propionic, lactic, etc.

Hankin, in a paper published in the past year, suggests that the germicidal substance is a special secretion of the eosinophile granular cells; according to his theory the granular matter of these cells is the antecedent of the germicidal substance.

In summing up the evidence we may summarize as follows:

1. It has been incontestably proven that blood-serum contains a substance which possesses considerable germicidal power.

2. Buechner has demonstrated that pepsin does not affect or extract the active germicidal constituent from blood serum; ergo, this active constituent cannot be serum albumin, because pepsin converts it into peptone which is especially favorable to the development of germ life.

3. A temperature of 55°C., as Buechner and others have demonstrated, destroys or impairs the germicidal activity of blood-serum. It is probable then that the substance is a proteid.

Vaughan adds to these a statement that the only proteid likely to be present in blood-serum, and which is not destroyed by peptic digestion, is nuclein. This conclusion would be rendered probable if he could isolate the nucleins themselves and demonstrate that they possess germicidal properties—if the residue remained inert it would strongly confirm the first result. To the solution of these questions Vaughan has given consider able time and attention. The results which he has obtained are exceedingly striking and hardly less than convincing. Suffice it to say that he has demonstrated that blood serum does contain a nuclein—he asks the interesting question, does it come from the disintegration of the polynuclear cells, or shall we regard certain white blood corpuscles as unicellular organs whose

function it is to secrete this nuclein? He has demonstrated by repeated experiments that this nuclein possesses considerable germicidal power. He has also made many experiments with various nucleins extracted from the testes, the thyroid gland and yeast cells and proves conclusively that they likewise possess marked germicidal power. Indeed it now seems that immunity depends largely upon cell-nucleins, as well as upon the reaction and composition of the fluids of the body, upon vital resistive power and cellular activity. Wooldridge of England has also obtained results which seem but to confirm those of Vaughan, to whom we owe a large part of our present knowledge of the subject.

The fact that the germicidal constituent of the blood-serum can be isolated and utilized has an important bearing upon therapeutics,—indeed it is exceedingly analogous to the advance which was made when it became possible to extract the active alkaloidal principles from crude drugs. Blood-serum therapy has been proven impracticable not on account of a lack of virtue but because of the large amount of the fluid which it is necessary to inject in order to secure favorable results. The isolation and use of nuclein now seems to indicate a method of avoiding this difficulty—it is even hinted that the future may witness the use of the various nucleins as therapeutic agents in the treatment of disease.

But persons or animals naturally susceptible to disease may, by means of certain processes, secure an immunity, usually termed acquired in contradistinction to

that which exists naturally in some species, races or individuals. It has long been a well-known fact that certain of the infectious diseases, such as typhoid fever, yellow fever, parotitis, pertussis, etc. confer upon the individual so infected a freedom from or immunity to subsequent development; this immunity while general is not always absolute.

Certain other infectious diseases such as epidemic influenza, croup, pneumonia, Asiatic cholera, etc. do not confer immunity against subsequent attacks. It is exceedingly probable, however, that in this latter case a certain degree of immunity of a limited duration is afforded, because we seldom have an individual stricken with these diseases twice during the same epidemic. If such immunity is afforded it must be transient in nature. Even that afforded by the first class of diseases is not everlasting in its effects, for a man may have small-pox a second time if several years have elapsed since the first attack and provided also tha, the second exposure brings him in contact with a virulent form of infection or consists of an exposure through an unusually long period or at a time when health and vitality are impaired by any cause. Until the discovery of Jenner the only form of acquired immunity known was that obtained or conferred by an actual attack of the disease ending in recovery. We now know at the present time that immunity is also conferred by vaccination with a modified form of infection; by the introduction of a small number of virulent germs followed by a successive inoculations with larger numbers until a tolerance,

as it were, is established; and by treatments with sterilized germ-cultures.

Pasteur (1880) produced immunity by inducing a mild attack by means of an injection of attenuated cultures. He, in this way, made successful inoculations against chicken-cholera and anthrax. Emmerich and his pnpils succeeded in immunizing animals to swine-erysipelas by employing small numbers of the virulent germs and gradually increasing the dose. This is practically the *rationale* of Pasteur's method in rabies. However, the immunity conseqnent upon inoculation with a germ full of virulence is not only more marked than in the case of the use of modified or attenuated cultures but is also more lasting in its effect. Ogata and Jasuhara have fully demonstrated the fact that anthrax cultures in the blood of an immune animal (such as the rat, dog or frog) become attenuated as far as their pathogenic power is concerned. Also that injection of these cultures, so attenuated, into the blood of a susceptible animal gives rise to a mild attack followed by immunity. Moreover that if even a drop of blood from the dog or frog be injected into a mouse, before or after the latter is inoculated with a virulent culture of the anthrax bacillus, that it proves protective against a fatal attack, the mild attack thus induced being followed by immunity. Similar results have been attained by Behring and Kitasato.

Tizzoni aud Cattani fnid that in the case of tetanus, the blood-serum of an immune animal will protect either against the living germ or the germ-free culture.

Salmon and Smith (1886) succeeded in rendering pigeons immune to hog-cholera by inoculations with sterilized cultures of the bacilli. Roux (1888) obtained similar results in the case of anthrax and Behring and Kitasato in the case of tetanus and diphtheria.

Fraenkel determined that 10–20 c. c. of a three-weeks old culture of diphtheria babillus, if heated to 65° or 70° for one hour, and then injected into a guinea-pig, secures immunity against subsequent inoculations by the virulent germ if such subsequent inoculations are not made sooner than the fourteenth day after treatment by the sterilized culture. He declares that in his opinion the cultures contain *two* special albuminous bodies, one toxic in nature and destroyed or rendered innocuous by a temperature of 65°–70° C and the other conferring immunity yet retaining its properties at that temperature.

Tizzoni, Cattani, Klemperer, Ogata, Jasuhara, Kitasato, Behring, Buechner and others hold to a belief that some substance is formed in the blood of the immune animal and that this substance has the peculiar power of neutralizing the toxic products of pathogenic micro organisms. Some conclude that this effect is not due to ptomaines but to proteids, though the latter need not necessarily be direct products of the germ against which immunity is sought nor indeed even necessarily of bacterial origin. Others however hold that this immunity-conferring substance partakes of the nature of an antitoxin. Sternberg says on this point: "The experimental evidence detailed gives strong support to

the view that acquired immunity depends upon the formation of antitoxines in the bodies of immune animals. As secondary factors it is probable that tolerance to the toxic products of pathogenic bacteria and phagocytosis have considerable importance, but it is evident that the principal role cannot be assigned to these agencies."

Others, like Vaughan, Novy, McClintock and Wooldrige, believe immunity resides within the cell substance, and cite the germicidal power of the nucleins of blood, testicle, thyroid gland, yeast and other cells. Their side of the question is certainly upheld by experimental proof at least as strong as that of those advancing the antitoxin theory alone.

If a sterilized culture affords immunity what constituent of it possesses this peculiar property? All are agreed that it is not the function of ptomaines. Vaughan says strikingly:

"We can answer the question as to which constituent of sterilized cultures gives immunity with considerable confidence if we recognize the following facts:

1. Marked artificial immunity to an infectious disease has not been obtained except by the introduction into the animal of the germ substance, either enclosed in the cell wall or in solution.

2. Sterilized cultures contain the germ substance in one or both of these forms.

3. The same immunizing substance exists in the bodies of bacteria grown on solid media and killed by the action of chloroform.

4. The same immunizing effects, varying, however,

in degree, are obtained with the bodies of the dead bacteria morphologically intact or in solution, with living bacteria modified and reduced in virulence and with very small numbers of the virulent germ."

From this he very logically concludes that the immunizing substance is a constituent of the bacterial cell itself; and further that as each kind of germ has its own peculiar poison, conferring immunity when ex hibited in small doses; the poison cannot come from the cell wall, nor can it be a decomposition product of bacterial activity but an essential, characteristic portion of the cell itself, to which is due its distinctive properties. He believes this to be the nuclein. Certainly his prem ises are peculiarly upheld by facts, for all of the methods of producing immunity depend upon the introduction of the germ-substance into the body. Immunity conferred by an attack of disease is certainly caused by an introduction of germs which are not only living but more or less active in virulence. That which is induced by vaccination or inoculation by attenuated cultures is due to the introduction of germs which are living but whose virulent activity is more or less modified or reduced. That which is induced by inoculation with sterilized cultures is due to the introduction of the germ substance (or as Vaughan says, the germ-nuclein) so modified that it is no longer capable of reproduction.

True it is that a susceptible animal may be rendered immune by treatment with the blood serum of an immune animal. For example a horse is rendered im-

mune to tetanus by treatment with the modified bacterial proteid and from these treatments it results that an immunity-conferring substance is generated within the horse and circulates in its blood. If now this blood-serum of the horse be injected into a mouse the animal becomes, under certain conditions immunized to tetanus. But as Vaughan most aptly says—"The immunity actually does not belong to the mouse. It still belongs to the horse. *It is stolen property and will soon be lost.*" The immunity-conferring substance is formed by the cells of the horse not of the mouse. Behring says that subsequent inoculation of the mouse may awaken its cell activity and the immunity which then results is the direct property of the mouse, *but this does not become true prior to the introduction of the germ.*

Upon what does the inciting cause act in the production of immunity? Tizzoni and Cattani have demonstrated that rabbits cannot be immunized to tetanus after removal of the spleen. Lindemann and others have shown that a dog which has undergone extirpation of the thyroid gland will not stand the doses of caffein which the same dog was able to bear prior to extirpation. The effects of extirpation, or atrophy of the thyroid gland, are now well known, as are also the brilliant results following the administration of the gland in certain diseases. It is suggested that these organs are the sources of nucleated leucocytes,—these differ from the red corpuscles in that they possess nuclei. This naturally suggested that nuclein might play an important role in the production of immunity. This

thought occured to Brieger, Wasserman and Kitasato; they obtained negative results but is is significant that they used a temperature of 100° C in the elaboration of their preparations—we know now that a temperature of 55° C seriously impairs indeed almost destroys their virtues. Wooldridge of England, whose work seems to have been entirely overlooked, obtained very favorable results as indeed has Vaughan even more recently. We may now consider it conclusively proven that the blood-serum, thyroid gland, spleen, marrow of bones, etc. have considerable germicidal power and this power is possessed by their nucleins. That the nucleins do exert a powerful influence in immunity Tizzoni and Cattani have shown by failures to produce immunization of rabbits to tetanus when the spleen had been removed. We now know that Nature has provided special physiological guards against infection by the ordinary channels and further that she has supplied general physiological guards in the nucleins whose germicidal power is dependent largely upon vital cellular activity. This forces us to the conclusion that immunity is in a large measure due to the production of antagonistic substances which are produced by the stimulation of certain organs, chiefly the spleen, the thyroid gland and marrow of bones which manufacture nucleins—does it not seem reasonable then that these antidotal substances should be nucleins? Their kind and amount then would depend upon the nature of the incitant and the organ or organs specially incited. This would indicate that the processes of Nature are eminently conservative, that they

are constantly striving for the attainment of such an ideal state of health as would render the system proof against hostile attacks of pathogenic organisms. It is a question whether this end might not be attained were it not for our vitiation and antagonism of Nature's own efforts by our habits and frequent infractions of all hygienic law. Clearly then anything which depresses vitality predisposes to susceptibility to disease while it is only to an exaltation of vitality that we can look for immunity.

VII.—Antiseptics and Their Relative Value.

Antisepsis is a condition in which the development of micro-organic life is retarded or rather prevented. The germ is not necessarily destroyed or killed; it is sufficient simply to arrest and prevent its development, its power of exercising the reproductive functions. An antiseptic is an agent capable of preventing putrefaction, that is, the growth of those organisms which cause putrefaction. If the agent also possesses the power *to kill or destroy* organisms, it is germicidal in effect although, of course, antiseptic; because a substance which possesses the power of destroying the organisms which cause putrefaction possesses the power, *ipso facto*, of preventing putrefaction. All germicides are necessarily

antiseptics but all antiseptics are not necessarily germicides—all potatoes are vegetables but all vegetables are not necessarily potatoes. In order to demonstrate *antiseptic* power it is only necessary to demonstrate or show that the substance is capable of preventing the exercise of those functions of bacterial activity which usually result in decay or putrefaction. The germ is thus rendered innocuous or harmless by inhibition of its normal vital activity. When the inhibiting condition, the actual presence of an antiseptic substance, is removed then the interrupted processes may supervene. Thus alcohol, sodic chlorid, sodic tetraborate, ferrous sulphate and many other substances commonly used as germicides do nót, even in concentrated solutions, destroy the spores of various germs, hence they are not true germicides. The true germicide kills or destroys the microbean element, rendering future development an impossibility except by renewed infection. The action of an antiseptic is very similar to that of judicial incarceration, in which the offending entity is isolated and shorn of his social and political functions—he is rendered incapable of doing harm. Germicidal action on the other hand is somewhat analogous to judicial execution—the offending entity is destroyed. An antiseptic substance must not only have the power of preventing the growth of putrefactive organisms but must also be capable of exercising such restrictive power even in culture media favorable to their growth, development and proliferation.

So many persons discuss asepsis and antisepsis as

though antithetical terms. Asepsis is, of course, a desirable, an ideal condition and antisepsis is a means to that end. Most wounds and injuries are infected before coming under the care of the physician or surgeon, there is no possibility of asepsis, in a strict sense. The germ has already gained access, no opportunity having been offered the physician to exclude it. Infection is so exceedingly insidious, even in conditions where everything seems favorable to the success of aseptic procedures, that it certainly seems rational to err, if at all, upon the safe side by a conjunction of asepsis and antisepsis. In so-called aseptic procedures everything is dependent upon sterilized dressings, sterilized instruments—sterilized by what means? Either by the *antiseptic* action of moist heat or by the use of antiseptics themselves. It is exceedingly difficult to say where asepsis ends and antisepsis begins, for asepsis is usually attained by an *antecedent* antisepsis.

Undoubtedly the greatest of all antiseptics and germicides is health. It is only when the natural and normal efficiency is vitiated that Nature becomes dependent upon Art. The healthy tissues of the human body neither harbor infectious organisms nor favor or aid their subsequent development when introduced. Indeed there cannot now be the slightest doubt but that the highest type of histologic vitality, which we commonly term health, is highly prejudicial to the action of pathogenic bacteria. Furthermore when such have been introduced within the system, either by accident or design, they are quickly destroyed either in the circula-

tion or tissues or else discharged through the various emunctory channels. Cunningham and others have proven that bacteria are frequently destroyed in the blood; Vaughan too has demonstrated the germicidal power of the nuclein of blood-serum. Wyssokowicz claimed that those organisms which are not destroyed rapidly in the blood are deposited materially in the tissues, just as is done in the case of particles of pigment. He introduced anthrax bacilli, in small quantities, into the blood of rabbits and found that they disappeared in twenty-four hours; he claimed however to have found them deposited in large numbers in the liver and the spleen. Cheyne, Ogston, Ribbert and others have proven the possibility of excretion of germs by the genito-urinary tract, demonstrating their actual presence in the kidneys and urine. It has also been proven that germs may be excreted by the mammary, and possibly also the parotid glands. Indeed Passet and Longard have shown that, in the case of mice at least, it was possible for cocci to be excreted by the conjunctival membranes.

The medical literature of the past few years contains many references to the germicidal properties of blood-serum. May there not have been something of fact as well as fancy in the results ascribed to the old fashioned and almost obsolete practice of sending invalids with impaired vitality to *abattoirs* to partake freely of the warm, freshly drawn blood of recently slaughtered animals? Not only has the blood-serum germicidal properties but those of different animals vary in the intens-

ity of their powers. Thus the common domestic rat is highly resistant to the action of most bacteria which are pathogenic in their effects upon the human organism.

So it seems that all of the normal functions of the body work together for its good in the preservation of its hygienic and vital activity. When we consider how slight a cause may interrupt the normal operations of this delicate and highly complex machine called the human organism, how careful and watchful of its health we should be. These natural conditions and beneficient tendencies of the organism may be perverted by various causes such as injury, cold, inflammation, embolism, local or general depression of vitality, etc. For centuries men have climbed mountains, crossed oceans, bridged chasms, delved into the bowels of the earth, burned the midnight oil, courted death in a thousand forms in a vain and endless search for the illusive and delusive "Elixir of Life." All this time they labored in ignorance of the fact that the treasure sought lay constantly within their reach—nay, more—pulsing through their very beings. And yet—and yet—they found it not.

For the most favorable development of germs and an exercise of vital activity certain physical conditions are necessary. Thus there must be (*a*) a certain degree of temperature, (*b*) a certain degree of moisture and (*c*) a suitable nutrient medium; a combination of these three conditions produces ideal surroundings for the development of micro-organic life. The growth and develop-

ment of germs can then be restrained physically by (*a*) elevation of temperature, (*b*) depression of temperature, (*c*) absence of nutrient media, and (*d*) absence of moisture—indeed they can be destroyed by sufficient elevation of temperature. Clearly then, where surroundings are favorable, even physical conditions may sometimes be used as antiseptic agents. Some few germs, however, are able to multiply at the freezing point (0° C., 32°F.), while others possess powers of proliferation at temperatures as high as 60°–70° C., (140°–158° F.)—we must remember in this connection that the freezing point is zero on the Centigrade scale in common *scientific* use and thirty-two degrees above zero on the Fahrenheit scale which is in commen *domestic* use; and that the temperature at which water boils is one hundred degrees above zero on the Centigrade scale and two hundred and twelve degrees above zero on the Fahrenheit scale. The temperature favorable for the growth of most bacteria is 20°–40° C., (68°–104° F.), but as a rule most parasitic species require a temperature of 35°–40° C. (95°–104° F.), that is about the normal bodily temperature. In very high elevations of bodily temperature, if the blood be not altered, its germicidal power is increased owing to the inhibiting influence of elevated temperature; this advantage is inappreciable however because of the concomitant depressed vitality of the body itself. Let us proceed then to a consideration of the virtue of physical agents as antiseptics.

Cold.—The weight of experimental evidence goes to show that low temperatures do not usually kill bacteria,

although elevated temperatures do. Frisch (1877) exposed various cultures to a temperature of 87° C. *below the freezing point*—he obtained this exceeding low temperature by the evaporation of liquefied carbon di-oxid. Even after exposure to such a degree of cold he found that micrococci and bacteria multiplied abundantly when again placed under favorable conditions. Prudden found that some species resisted low temperature while others did not. He based this latter conclusion upon the fact that some bacteria died, although he did not clearly prove such to be the result of the low temperature. As Sternberg aptly says, there would probably have been a similar diminution in the cultures, more especially if old, owing to an exhaustion of pabulum; this of course might be independent of freezing for bacteria, like higher plants, die in time—indeed continued vitality depends upon continued reproduction. Prudden also found that repeated freezing and thawing was more fatal to some forms, such as the typhoid bacillus. Cadeac and Malet kept portions of a tuberculous lung frozen for four months; at the end of that time the injection of even a small quentity into guinea-pigs, was capable of producing tuberculosis in the animal so inoculated and infected.

Moist Heat.—The burden of experimental evidence seems to indicate that the thermal death point of bacteria is comparatively low when subjected to the influence of *moist* heat. Indeed a large number of pathogenic organisms are killed by exposure to temperatures of 55°–60° C. (131°–140° F.) for ten minutes; some are

killed at even slightly lower temperatures and by extending the *time* of exposure it is exceedingly probable that somewhat lower temperatures still may effect the same result. Non-pathogenic bacteria as a rule require higher temperatures, such as 58°–65° C. (136 4°–149° F.), and some even higher still to effect their destruction. Globig has obtained several species, from the soil, which grew at 50°–70° C. (122°–158° F.), while Miquel (1881) found a motionless bacillus in the water of the Seine which grew luxuriantly in bouillon at 69°–70° C. (156.2°–158° F.).

The resistant powers of spores are, as a rule, greater than those of germs themselves; however, these resistant powers vary in strength among the various species. Even the spores of all known pathogenic bacteria are quickly destroyed by exposures (even though short, Sternberg says that five minutes is fully sufficient) to a temperature of 100° C. (212° F.), namely that at which water boils. The spores of the *Bacillus anthracis*, the most resistant and tolerant of all the commoner pathogenic organisms, are killed in four minutes by exposure to moist heat at 100° C. (212° F.). The results obtained by Yersin and Sternberg seem to indicate that the spores *Bacillus tuberculosis* are destroyed by an exposure of ten minutes to a temperature of 70° C. (158° F.), although Voelsh claims that a temperature as high as 100° C. (212° F.) is insufficient for this. We may however reasonably and certainly rely upon the fact that exposure to moist heat at the boiling point (100° C. or 212° F.) is sufficient to destioy all pathogenic

germs and spores in a few minutes. Some non-pathogenic germs and spores resist this temperature but being non-pathogenic in character (that is, incapable of causing disease) the fact possesses little practical importance to the physician and surgeon.

Dry Heat.—Koch and Wolffhuegel (1881) fully demonstrated that when micro-organisms are exposed, in a dessicated condition, to the influence of dry heated air a higher degree of temperature is required for their destruction than when they are moist, or exposed to the action of hot water or moist steam. These deductions were reached as the direct result of experiments made with a large number of pathogenic and non-pathogenic species.

Exposure for an hour and a half to a temperature of 78°–123° C. (172.4°–253 4° F), and for one hour to a temperature above 100° C. (212° F.) failed, in the case of *dry* heat, to kill various non-pathogenic germs but did destroy the bacteria of mouse septicemic and rabbit septicemia. A temperature of 120°–128° C. (248°–262.4° F.) and an exposure of an hour and a half was required to insure the destruction of all species treated in the absence of spores. The spores of *Bacillus anthracis* and *Bacillus subtilis* resisted this temperature, requiring a temperature of 140° C. (284° F.), and an exposure of three hours to effect their destruction. But this temperature is decidedly injurious to bedding, clothing, and most of the commoner domestic objects requiring disinfection. Since the specific germs of diphtheria, typhoid fever, erysipelas and cholera do not form

spores, objects infected by these diseases may be disinfected by dry heat at a temperature of 120° C. (248° F.) and an exposure of two or three hours.

Dry heat is not only less active than moist heat but is also less penetrating, especially so in the case of folded blankets and other articles fashioned of poor conductors of caloric. Koch and Wolffhuegel demonstrated this by placing registering thermometers within folded blankets and various packages. After exposure for three hours in a hot air oven to a temperature of 133°C. (271.4°F.) the thermometers showed that a sufficient temperature to kill bacteria had not been attained internally. Rohe conducted similar experiments, subjecting rolls of blankets to a temperature of 280°F. (137.8°C.) for three hours; he found that they were but very slightly affected in their interior.

Hence it seems that moist heat is much more effective as a germicidal agent than dry heat. In the case of moist heat the liquid pierces or penetrates mechanically thus carrying the heat to every portion; it must be evident then that to secure thorough disinfection of clothing, blankets, sheets, etc., boiling is necessary.

Dessication.—Cultures in the moist condition may retain their vitality for a considerable length of time. Paul says that the typhoid bacillus has retained its vitality more than six months. Dessication is however quickly fatal to some pathogenic bacteria, such as the cholera spirillum which Paul says perishes after dessication for one half hour at the ordinary temperature. The typhoid bacillus withstands this treatment for eight

or ten weeks, the bacillus of diptheria four or five months and the bacillus of tuberculosis five months. Spores however retain their vitality, even in a dessicated condition, for a great length of time.

Light.—Downes and Blunt (1877), in a report to the Royal Society of London, first called attention to the fact that light has an injurious effect upon bacterial life —indeed they even claimed that cultures might be sterilized by exposure to direct sunlight. Tyndall verified these claims to some extent by experiments showing that development is restrained at least by direct exposure. This does not seem altogether improbable when we remember that many of the bacteria are lower forms of vegetable life devoid of chlorophyll and on this account would thrive better in absence of direct sunlight. Then too we know that light nndoubtedly has certain definite actinic and chemic powers.

Gaillard's experiments seem to conclusively prove the germicidal power of sunlight in the presence of oxygen. Geisler thinks that such effects are partially due to the action on the gelatin culture media and Koch confirms this result with his experiments with the tubercle bacillus.

Sternberg says that exposure to sunlight is one of the most potent and the cheapest of agents for the destruction of pathogenic bacteria and is a practical and valuable hygienic measure.

Electricity.—Attempts have been made recently to ntilize this force for the destruction of germ life. Recent experiments make it seem doubtful that the elec-

tricity acts directly; if so, strong currents and moderately long exposures are essential. It is, or seems reasonably certain, that the chief virtue of electricity lies in the virtue of the products of its electrolytic action. For instance the decomposition of aqueous media would yield *nascent* oxygen and hydrogen, the former of which possesses undoubted antiseptic value.

The number of antiseptic substances proposed and recommended by various authors and experimenters is considerable and is furthermore constantly increasing without cessation. It is important then that the physician and surgeon should be moderately familiar with these substances, or their comparative values at least. These different products do not act uniformly in their resistance to different pathogenic micro-organisms; one agent may be exceedingly active against one species and inert towards other. Then again spores are often and indeed usually more resistant than the parent germ. Not only do becteria vary in their resistive power to the action of antiseptic substances but the activity and value of the latter may be influenced by various surrounding conditions. Chief among these are the nature and quantity of the material with which the bacteria are associated. Some disinfectants act by an oxidation of the offending entities and a mutual destruction of the germ and germicide results, as is the case with potassic permanganate. But this substance oxidizes organic matter of all kinds; hence, if organic matter exists associated in quantity with germs the value of the germicide may be impaired because it may oxidize the or-

ganic matter and be itself destroyed before the bacteria are affected. Then again we must consider the chemical nature of the substances thus associated with bacteria. For example, silver nitrate is a very efficient germicide and antiseptic but if used to disinfect urine its germicidal efficiency would be highly impaired if not entirely counteracted by the action of the sodic chlorid of the urine upon the silver salt, the latter being precipitated as an insoluble and comparatively inert argentic chlorid, thus—

$$Ag\ NO_3 + Na\ Cl = Ag\ Cl + Na\ NO_3.$$

Moreover the presence of albumin may inhibit the action of mercuric chlorid ($Hg\ Cl_2$) and other metallic salts. Van Ermengem states that the spirilla of cholera are destroyed *in bouillon* in one half hour by mercuric chlorid in the proportion of 1:60,000; while *in blood-serum* a proportion of 1:800 was required to effect the same result that is, a solution nearly seventy-five times as strong in the latter case as in the former. Why is this? Bouillon, as has been conclusively proven, consists chiefly of the extractive salts of beef, it contains little or no albumin, being analogous in chemical composition to urine. Blood-serum is rich in albumenoids—the inference is obvious.

Some agents are rapid in action, others extremely slow. Then again different species of bacteria require different exposures, some of short duration while others require a lengthy exposure; this is on account of the varying resistive powers. Nissen found that a solution of "chloride of lime" (the *hypochlorite* is what is really

meant) containing .12% destroyed anthrax bacilli in one minute and the cholera spirilla and typhoid bacilli in five minutes. Other agents might require several hours. As a rule the stronger the solution the shorter the time of exposure required and *vice versa.*

The temperature at which an exposure is made may directly affect the result. Very high temperatures inhibit vital activity (and indeed may even destroy), hence under such conditions of restraint of resistive power we would naturally expect to find the germ especially susceptible to antiseptics.

The number of antiseptic substances is legion and as no definite and rational method for grouping them has as yet been devised, perhaps an alphabetic arrangement may prove most convenient for their individual consideration.

ACETANILID, (ANTIFEBRIN), also termed *Phenyl acetamid.* The drug is chemically an anilin in which one atom of hydrogen has been displaced or replaced by the compound radical acetyl, thus: $NHC_6H_5C_2H_3O$. It is a white, crystalline substance when pure, occurring in brilliant rhombic plates. It is usually prepared by the action of strong acetic acid upon anilin and by prolonged contact with hydrochloric acid is resolved into its constituents. Acetanilid is insoluble in water at ordinary temperatures but is readily soluble in chloroform and ether; it is also somewhat soluble in alcohol, in the proportion of 1:3.5. It is chiefly used as an antipyretic but has been recommended as a local antiseptic. Its abuse gives rise to toxic symptoms.

Acetic Acid.—Pure acetic acid is a colorless liquid, having a peculiar pungent odor like that of strong vinegar (which usually contains 4–6% of acetic acid), free from empyreuma and possessing an intensely acid taste. It is, in concentrated conditions, somewhat escharotic and corrosive. It is the second member of the group of so called "fatty acids", resulting from the direct oxidation of ethyl aldehyd or the ultimate oxidation of ethyl alcohol. Its chemical formula is $HC_2H_3O_2$ or CH_3 COOH. The acid as usually sold contains about thirty-six per cent of monohydrated acetic acid; absolute acetic acid is a crystalline solid somewhat analogous to ice in appearance and hence termed *glacial* acetic acid. In a concentrated form it is a corrosive poison.

Koch found that 5% failed to kill anthrax spores even after five days exposure. Abbott found that the same spores resisted the action of 50% glacial acetic acid, even after an exposure of two hours—indeed the spores of the anthrax bacillus seem to possess peculiar resistant power to the action of the acid. Kitasato however found that 3% would kill typhoid bacilli in five hours while 2% effected the same result in the same time with the spirilla of cholera.

M. Haschimodo has reported from Paris that a vinegar containing 2:2–3.3% of acetic acid saturated with a pure culture of the spirilla of cholera can, after an interval of fifteen minutes be inoculated into animals without danger—or even eaten with impunity by human beings.

In 1874 Klein made the statement that corrosive sublimate had no more germicidal value than vinegar. It is interesting to note that McClintock, in testing the truth of this statement, found that vinegar containing 6:3–7% of acetic acid prevented the growth of micro-organisms *as effectually as a* 1:1000 *solution of corrosive sublimate* These results completely verify Klein's statement.

Crude acetic acid (pyroligneous acid), sometimes called "wood vinegar," is the crude product obtained when wood is subjected to destructive distillation. It is a dark-brown liquid, almost black, the color depending upon the amount of tar contained; it possesses a characteristic, penetrating, smoky odor very like that of burnt wood. The tar present is rendered soluble by the acetic acid—indeed acetic acid has also the power of effecting a partial solution, at least, of albuminous substances; the presence of this tar, no doubt, adds much to the antiseptic qualities of the liquid. Some attention has been paid to this substance during the past year; its accessibility, its cheapness and other properties would make it very desirable if subsequent researches and experiences can indubitably prove that it has decided antiseptic qualities. During the past year it has been constantly used in various morgues and hospitals and, as Squibb says, has worked admirably.

Acetone.—Produced by the dry distillation of an acetate, such as calcic acetate; its chemical formula is $(CH_3)_2CO$. Koch has demonstrated that anthrax spores grow freely after two days exposure to the action of

acetone and that they are not destroyed by five days exposure, although their action is somewhat enfeebled.

ALCOHOL.—Chemically the hydroxid of ethyl (the second member of the radicals of the marsh-gas series), its chemical formula being C_2H_5OH. The properties of this substance are too well known to need description. It was one of the first antiseptics used, though now almost entirely discarded. It was advocated in a pamphlet by Bataille (1859) and adopted by Nelaton (1863) and also by Le Fort. Schill and Fischer demonstrated that tuberculous sputum had its infectious nature destroyed by alcohol, but that five volumes of absolute alcohol were necessary to destroy the bacilli, equal volumes being inefficient. Pure cultures of the bacillus were completely sterilized by five minutes exposure to the action of absolute alcoho . Koch found, however, that even an exposure of one hundred and ten days had no effect upon anthrax spores.

ALUM.—The alums are hydrated double sulphates of aluminum and some other positive radical—more commonly either potassium or ammonium, thus: $K_2Al_2\ 4\ (SO_4)\ .24H_2O$ or $(NH_4)_2\ Al_2\ 4\ (SO_4)\ .24H_2O$. Miquel has determined that while alum is not germicidal it is antiseptic and that a proportion of 1:222 is sufficient to restrain putrefactive decomposition in bouillon.

ALUMINIC ACETATE.—$Al\ (C_2H_3O_2)_3$. Kuhn has determined that it is antiseptic in action in the proportion of 1:5,250 while De la Croix places its antiseptic power at 1:6,310.

ALUMINIC CHLORID.—$AlCl_3$. Miquel has deter-

mined that this substance is antiseptic in the proportion of 1:714.

ALUMNOL.—This new aspirant is an aluminum salt of naphthol-sulphonic acid. It is a reddish white, non-hygroscopic powder, darkening in color by age or exposure. It has but recently been introduced to the notice of the profession; this was done at the late International Congress of Dermatologists in Vienna. The drug is readily soluble in cold water, much more so in hot water, less so in glycerin and alcohol and insoluble in ether. It has an acid reaction and precipitates gelatin or albumin, this precipitate being soluble in excess of gelatin or albumin and thus allowing penetration of the drug within the tissues by virtue of this peculiar property. It is closely allied to *Sozal* and *Sozo iodol* but is much more astringent than either.

Eraud, of Paris, has used the drug extensively and declares that it neither irritates nor gives pain. Spengler found that it is comparatively free from poisonous properties but that when large quantities were introduced beneath the skin or within the stomach the kidneys were apparently affected—although Spengler does not state it, this is probably due to renal elimination. Indeed Drs. G. B. Wood and A. Stille hold that other salts of aluminum, analogous to alumnol, are found in the urine of persons taking them.

The drug has not, as yet, been largely used in this country. Blount and Delavan, of New York City, reported favorable results from its use at the late Pan-American Medical Congress. Dr. Delavan says how-

ever that he could not put it on as high a plane of usefulness as was claimed for it. Its high price (costing *four* times as much in this country as in Germany) also stands in the way of its general use. Good reports have been given of its use in gynecology and otology, but it is probably too early as yet to put a proper estimate upon its value.

AMMONIA.—Occurs as a gas (NH_3) and in aqueous solution (NH_4OH, ammonic hydroxid, ammonic hydrate and "ammonia water"). Kitasato found that .3% would kill the typhoid bacilli and the cholera spirilla after an exposure of five hours.

AMMONIC CARBONATE.—$(NH_4)_2CO_3$. Kitasato found that a solution of 1:125 restrained the development while 1:100 killed the typhoid bacillus in five hours. A strength of 1:77 was required to kill cholera spirilla in the same time.

AMMONIC CHLORID.—NH_4Cl. Koch found that a 5% solution did not kill anthrax spores even after twenty-five days exposure. Indeed the substance has no germicidal power, but Miquel gives it antiseptic power in the proportion of 1:9.

AMMONIC FLUO-SILICATE.—$(NH_4)_2SiF_6$. Strongly germicidal and antiseptic. Faktor demonstrated that a 2% solution killed anthrax spores after from one-quarter to three-quarters of an hour exposure. A solution of 1:1-000 prevented the growth of the bacilli of anthrax and typhoid fever, even in nutrient gelatin media.

AMMONIC SULPHATE.—$(NH_4)_2SO_4$. Koch found that a 4% solution required five days, to kill anthrax spores.

Miquel found the substance antiseptic in the proportion of 1:4.

ANILIN DYES.—Those used as antiseptics are chiefly rosanilin, methylene blue, methyl violet and methyl yellow, the two latter being sold by Merck as a patented preparation under the name of *Pyoktanin.* These substances are all intense coloring agents, even in minute quantities. Sternberg says that recent researches indicate that these agents possess decided germicidal powers, even in dilute solution. Boer found that the variety known as "malachite green" was even more efficacious than methyl violet, yet gave them both a germicidal value far above that of mecuric chlorid. Roswell Park after a most exhaustive series of experiments denies utterly all such claims to efficiency. He says: "I have been led to detail my experiments with the material not merely as illustrative of a method, but because numerous articles have recently appeared with reference to it, in some of which the writers appear to have allowed their verdicts to be influenced by what the manufactures have claimed for it, rather than by anything like a scientific test of its genuine value.

I would not wish to be understood as inveighing against a certain well-known value which most all of these anilin preparations have in common. In 1872, Dr. Chas. Curtman, of St. Louis, made known the fact that they possess antiseptic properties, and common experience confirmed his statement. Stilling has gone so much further as to assert that they are absolutely non-poisonous, a statement which is far from justified by facts. * *"

On the whole, then, it has but few qualities by which we are to commend it above numerous other drugs of its general class, while in all that may answer to the more scrupulous demands of aseptic surgery it has proved in my hands—as in those of others who have tested it from the purely clinical standpoint—disappointing." (See *Pyoktanin* and *Methylene blue*).

ANILIN OIL.—Riedlin says that anilin water, in the strength of 1:5, has the power of preventing the development of bacteria even in nutrient gelatin media.

ANISIC ACID.—$C_6H_4OCH_3COOH$. This substance is a constituent of the oils of anise and fennel and is an isomer of methyl salicylic acid, which latter is closely similar to synthetic oil of wintergreen (a compound ether, or ester, namely methyl saliclyate). The acid occurs in the form of colorless prisms which are insoluble in water but are freely soluble in hot and cold alcohol. The drug possesses antipyretic as well as antiseptic properties; it has been used in the treatment of wounds.

ANNIDALIN.—This substance is frequently confounded with *Aristol* which it closely resembles chemically and physically. Annidalin is dithymol *tri*-iodid while aristol is the *di*-iodid. It is a reddish-brown powder in which light and heat cause the liberation of iodin. It is insoluble in water, slightly soluble in alcohol and readily soluble in ether and chloroform. Cerna says that aristol is only *slightly* soluble in chloroform; if this is so it would be a ready means of distinction between annidalin and aristol, since the former is freely soluble

in chloroform. But the manufacturers of aristol claim that it is freely soluble in chloroform.

Annidalin is used chiefly as a local antiseptic and dusting power, probably owing its chief virtue to the gradual decomposition and consequent liberation of iodin. It is proposed as a substitute for iodoform, but like the latter is practically devoid of active germicidal properties.

ANTHRAROBIN.—Also termed *Desozy-alizarin.* This substance, a derivative of phenol and allied to chrysophanic acid, is obtained from *alizarin,* the crystalline principle of the common madder-plant. It is a yellowish powder readily soluble in alcohol, glycerin and dilute alkaline solutions; sparingly soluble in ether and chloroform and insoluble in water or acids. It is used chiefly as an anti-parasitic in dermatology and has been of special value, it is claimed, in psoriasis, ptyriasis versicolor and also herpes; it is usually used in the form of an ointment.

ANTIFEBRIN, (see *Acetanilid*).

ANTIPYRIN, (*Analgesin*).—Also called *Phenazon, Methozin, Phenyl di methyl pyrazolon, Di methyl oxyquinizine* and *Dehydro di-methyl phenyl pyrazine.* It is a derivative of coal tar, its chemical formula being $C_{11}H_{12}N_2O$. Antipyrin is a white or reddish white, crystalline, odorless powder of somewhat bitter taste and used chiefly as an antipyretic and analgesic. It is readily soluble in cold water, rectified spirits, and chloroform—also in ether in the proportion of 1:50. It has been demonstrated that the drug also possesses antisep-

tic properties. Experiments seem to confirm the statement that, *in vitro,* it has the prower of destroying the diphtheritic bacillus in forty-eight hours.

ANTISEPSIN (ASEPSIN).—Called also *Para mono-brom phenyl-acetamid* and *Para-mono-brom-acetanilid* and having the chemical formula $C_6H_4BrNHC_2H_3O$. It occurs in odorless, tasteless crystals which are soluble in alcohol and ether, slightly so in glycerin and insoluble in water. It has been used in typhoid fever, pneumonia and phthisis and also locally in wounds and hemorrhoids. Has attracted but little attention.

ANTISEPTIN.—Called also *Zinc boro-thymo-iodid* and *Iodo boro thymolate of zinc.* It is not however a definite chemical compound, as either of these names would indicate, but a mixture of at least four definite and distinct chemical compounds. Its composition has been given by Squibb, Goldmann and Cerna as follows:

	SQUIBB.	GOLDMANN.	CERNA.
Zinc Sulphate,	85	85	80
Zinc iodid,	2½	2½	—
Thymol,	2½	2½	2
Boric acid,	10	10	10

It is apparently but little used and noticed and indeed can hardly be said to be in general use now.

ANTISEPTOL.—This substance chemically is the iodo-sulphate of cinchonin. It is a reddish-brown powder which is soluble in water, alcohol and chloroform. It is chiefly suggested as a substitute for iodoform.

ARBUTIN.—$C_{12}H_{16}O_7$. This substance is a glucoside,

found (about 3.5%) in the leaves of the common bearberry (*Arctostaphylos Uva ursi*) and in other plants, especially the members of the natural order *Ericaceæ*. It occurs in long, colorless and brilliant silky needles or bunches of such needles which are sparingly soluble in cold water, slightly so in ether and readily soluble in hot water and alcohol. The crystals have the formula $(C_{12}H_{16}O_7)_2 .H_2O$, but lose this water of crystallization at the boiling point (100° C.); they possess a bitter taste and a neutral reaction. This substance is chiefly employed in affections of the genito-urinary tract and is said to be a most valuable antiseptic in this respect. This effect is probably not due to direct action of the drug itself but to the *hydroquinone* ($C_6H_6O_2$) which is set free in the organism. When arbutin is boiled with dilute sulphuric acid or subjected to the action of emulsin or another ferment contained in the bearberry it is converted into *hydroquinone* and glucose. It has been proven by Von Mering and Steffen that the discoloration of the urine which ensues upon the administration of arbutin is due to the breaking up of the arbutin in the body into glucose and hydroquinone. This change probably takes place in the kidneys, as arbutin is free from toxic properties while, as Brieger, has demonstrated, hydroquinone is poisonous; Forster has shown that the latter is a powerful disinfectant and antiferment. It is stated that a one per cent solution will arrest putrefaction and alcoholic fermentation while one half per cent is sufficient to arrest butyric fermentation.

When administered internally usually about 75 grains *per diem*, in divided doses, are given.

ARISTOL.—Sometimes erroneously termed *Annidalin*. Chemically it is di-thymol di-iodid and consists of two molecules of thymol ($C_{10}H_{13}OH$) in which two atoms of hydrogen and two radicals of hydroxyl (OH) have been displaced by two radicals of iodoxyl (OI). The empirical formula then would be $C_{22}H_{24}(OI)_2$. It is a reddish-brown powder with an aromatic odor and is produced by the action of an aqueous solution of iodin in potassic iodid upon an aqueous solution of thymol in the presence of potassic hydroxid. It is readily soluble in ether, chloroform, collodion and traumaticin; slightly so in alcohol, and insoluble in water, glycerin and alkalies. It has been largely used as a local antiseptic, in the form of powder, solution and ointment, in many conditions—especially as a succedaneum for iodoform, which is unbearable on account of its intolerable and disagreeable odor.

ARSENOUS ACID.—This is the substance formerly termed "arsenious acid" but which the last edition of the Pharmacopeia changes to its present form by elimination of the letter "i". Arsenous acid properly so-called has the chemical formula H_3AsO_3, but its anhydrid (As_2O_3) is so frequently called by this name as to give rise to some confusion. The solution of the anhydrid in water gives a dilute solution of the acid however. Koch found that 10% destroyed the vitality of anthrax spores only after an exposure lasting ten days, no such result being produced in six days. Miquel has

deteimined that it is antiseptic in the proportion of 1.166.

ASAPROL.—Chemically this substance is *Calcium beta-naphthol alpha-mono sulphonate* and has the formula $Ca(OH.C_{10}H_6SO_3)_2 3H^2O$. It is a white scaly powder obtained by the action of heated sulphuric acid upon beta-naphthol and then forming the calcium salt by combination with the resulting acid. It is readily soluble in water and alcohol.

It is recommended as an antiseptic in solutions with a strength of 5%. It destroys cholera spirilla in strong solutions and prevents the growth of microbes in weaker solutions and is quite popular in France but has gained little or no foothold in this country.

ASEPTIN.—Is said to be an empirical mixture of boric acid, borax and alum. Is seldom heard of, clinical literature on the subject being somewhat scarce.

ASEPTOL.—Also called *Ortho phenol*, *Sulpho-carbolic acid*, *Sulphonic acid*, *Ortho-phenyl-sulphonic acid* and *Sozolic acid.* It is usually found in the form of small, deliquescent and crystalline needles or else, more frequently, as a heavy, reddish, volatile liquid nearly one and a half times as heavy as water and of a syrupy consistency. It has an astringent taste and an odor strongly resembling that of carbolic acid. It is obtained by the chemical action of equal parts of concentrated sulphuric acid upon carbolic acid in the cold; its chemical formula is $C_6H_4OHSO_3OH$. It is freely soluble in water, alcohol and glycerin. It is used internally in the form of a lemonade and locally in solutions of 1 to 10%.

According to Hueppe a 10% aqueous solution kills anthrax spores in ten minutes, but a 3–5% solution is a reliable disinfectant in the absence of spores. Squibb says that "It has not supplanted carbolic acid so far, however, although it has now had several years to fulfill the original expectation." In the last number of his "Ephemeris" he says that Aseptol "has not fulfilled its promised mission of supplanting carbolic acid and may now be considered on the retired list."

Baric Chlorid.—$BaCl_2$. The salts of barium have practically little or no use in medicine. Miquel has determined however that the chlorid has antiseptic properties in the proportion of 1:10.

Benzene (Benzol).—C_6H_6. A colorless volatile liquid, slightly lighter than water and obtained by the distillation of coal tar. Benzene or Benzol is a definite chemical compound and is not to be confounded with the commercial "benzine" used for the removal of grease, etc.; this latter substance is a complex mixture of the hydrocarbons of the marsh-gas series and is not a definite chemical compound but a mixture of compounds. Benzol has been used of late in the treatment of influenza. It is also used as a parasiticide; Sneguersky and others have reported the successful treatment of scabies (itch) by inunctions of benzol alone, or mixed with equal parts of fat. Redness of the skin is produced, by brisk friction with a thick cloth, before the application of the drug. Sneguersky finds that the pure article is best adapted for the treatment of the parasitic condition uncomplicated, but when accompanied by an eczema-

tous condition the best results are obtained when the benzol is conjoined with an emollient fat.

Koch made experiments with a view to deciding the germicidal power of this substance; he found that twenty days exposure was insufficient to kill anthrax spores.

Benzoic Acid.—$HC_7H_5O_2$ or C_6H_5COOH. This substance occurs naturally as a constituent of gum benzoin, which is the concrete juice of a tree indigenous to Peru. Benzoic acid may be prepared by the sublimation of this gum or it may be prepared artificially from naphthalene. It usually occurs in the form of white feathery crystals of a silky lustre and a fragrant aromatic odor due to the presence of a volatile oil—the pure acid is free from odor. It melts and volatilizes without decomposition at 250°. It is but slightly soluble in cold water, more so in warm or hot water and freely so in ether, alcohol, fixed oils and alkaline solutions. Benzoic acid is widely distributed throughout the vegetable kingdom, constituting the peculiar principle of all true balsams and is occasionally present in the urine of herbivora. In 1872 Dougall announced that benzoic acid is one of the most active of antiseptic drugs; this statement caused experimentation and investigation on the part of Bucholtz, Grube, Fleck and Salkowski, they were all unanimous in ascribing to benzoic acid a first rank as regards its efficiency in destroying bacteria and preventing putrefaction. In the majority of these investigations benzoic acid was found to be much more efficient than salicylic acid. Bucholtz found that while .02% of benzoic acid

had a very perceptible effect upon the development of bacteria their growth was entirely inhibited by .1%; he found also that sodic benzoate was no less effective than the acid itself. His experience with .1% is very similar to the result obtained by Miquel. The acid has the property of preventing the decomposition of animal fats and inhibiting the development of rancidity; it is much used, because of this property, as an ingredient of various ointments.

More recent and complete bacteriological investigations as to the action of benzoic acid determine, as Sternberg says, the entire absence of germicidal power although it possesses antiseptic properties. Miquel has determined that the substance is antiseptic in the proportion of 1:909, a result strongly similar to that of Bucholtz with a preparation containing .1% of the acid. The substance and its derivatives have been used in several of the zymotic diseases with asserted good results.

BENZO-NAPHTHOL.—Chemically this substance is the *benzoate of beta naphthol* and has the chemical formula $C_{10}H_7O.C_7H_5O$. It occurs in small, dull, white, odorless and tasteless crystals which are insoluble in water and ether at ordinary temperatures and freely soluble in alcohol especially when hot. It is said to break up in the intestinal tract into its constituents, as does salol. It is generally used as an antiseptic and is said to have afforded good results in the treatment of both simple and tuberculous enteritis. Benzo-naphthol possesses slight toxic properties. It has never been claimed by the most conservative that it will act beneficially in any

but mild cases, best in mild chronic cases, especially when treatment has been instituted sufficiently early—that is, before the micro organisms have multiplied to any great extent or have exhibited much activity by becoming firmly established in surroundings favorable to their rapid multiplication.

It is best administered in wafers in doses of 4 to 8 grains.

BENZO-PHENONEIDE.—This substance is a new compound, is obtained from anilin dye and is, chemically, *Tetra methylo-diapsido benzo phenoneide.* It has been accredited virtue as a microbicide when locally applied. It is but little used or heard of, although it is said to have given favorable results in the treatment of various affections of the optic tract.

BENZOYL-EUGENOL. — $C_6H_3.C_3H_5(OCH_3)CO_2C_6H_5$. This substance is a derivative of eugenol and benzoic acid; it occurs in the form of acicular, colorless and odorless crystals which are soluble in alcohol, chloroform, ether and acetone but insoluble in water. But little is definitely known about this substance as yet, except that it is being employed experimentally in the treatment of tuberculous conditions.

BENZOYL-GUAIACOL (BENZOSOL).—This substance is the *benzoate of guaiacol* and is analogous to *Benzoyl-eugenol.* It contains fifty-four per cent of guaiacol and is represented by the chemical formula $C_6H_4OCH_3OCOC_6H_5$. Benzosol occurs in small colorless, odorless and almost tasteless crystals, having a slightly aromatic flavor. It is practically insoluble in water but soluble

freely in hot alcohol, ether and chloroform. The alimentary juices split up the compound into its constituents and liberates the effective guaiacol under conditions that avoid the unpleasant taste and that reduce the local irritation which results when guaiacol itself is used. It has been used successfully, it is said, wherever creosote or guaiacol are applicable; it is said to be especially useful as an antiseptic in intestinal disorders and in phthisis pulmonalis.

Benzoyl-guaiacol is best administered in chocolate pastilles with peppermint oil or sugar, or else in powder of doses of 3–12 grains.

Betol.—Also known as *Naphtalol*, *Naphtosalol* and *Salinaphtol*. Chemically it is a salicylic of beta-naphthol, closely allied to salicylate of phenol (*Salol*), and is represented by the chemical formula $C_6H_4OHCOOC_{10}H_7$. When pure the substance occurs as a crystalline, colorless, tasteless and odorless powder which is insoluble in water and glycerine, slightly soluble in alcohol and turpentine at the ordinary temperature and readily soluble in boiling alcohol, ether, benzene and linseed oil. Betol has been favorably used as an intestinal antiseptic and also with advantage in vesical catarrh, cystitis and gonorrhea.

Betol can be administered in pill or in emulsion in doses of 2–5 grains. For making bougies or suppositories it may be mixed with cacao-butter in the strength of 1:4.

Borax.—This substance is the sodium salt of boric or boracic acid and is frequently, though most errone-

ously, termed "sodium borate" and "sodium bi-borate" —it is really the tetra borate although most others than chemists describe an entirely different body under this name. Its chemical formula is $Na_2B_4O_7.10H_2O$. It may be considered as four molecules of boracic acid (H_3BO_3) in which only two of the hydrogen atoms have been displaced by two atoms of sodium, producing a chemical compound whose formula would be $Na_2B_4O_7$, the remaining ten atoms of hydrogen uniting with the remaining five atoms of oxygen to produce "water of crystallization." Or it may be considered as the sodium salt of tetra boric acid, whose chemical formula is $H_2B_4O_7$.

Borax occurs in colorless, transparent crystals but is also sold in the form of a white, non crystalline powder. It is soluble in cold water, freely soluble in boiling water or warm glycerin and insoluble in alcohol. When heated it puffs up like alum, losing its "water of crystallization." It possesses antiseptic properties, although, as Sternberg says, even a saturated solution of the substance has no germicidal power. Miquel has determined that it is antiseptic in the proportion 1:14.

Boracic Acid (Boric Acid).—H_3BO_3. This substance occurs in glittering, scaly crystals; it is also found in natural solutions in volcanic regions, as in Nevada and California and the *fumeroles* and *soffiani* of Tuscany. It is soluble in 26 parts of cold water and 3 parts of warm or hot water, but is freely soluble in alcohol.

As an antiseptic Lister considers it almost as efficient as carbolic acid. By reason of its insipidity, its entire

freedom from odor and irritating properties and the almost utter absence of toxic properties, as well as its cheapness, it is of great utility as an antiseptic, though possessing little or no germicidal power. It is highly praised as an antiseptic and deodorant, arresting putrefaction and fermentation—the *Bacterium termo* seeming to exhibit special susceptibility to its action.

In the experiments of Dr. Walb, a solution of 2% distinctly checked the putrefaction of a solution of fibrin, while 5% kept it fresh for nineteen days. Buch oltz found .75% sufficient to prevent the development of bacteria. The experiments of Sternberg seem to show, as he himself says, that boracic acid possesses considerable antiseptic power but no great germicidal power. Rosenthal demonstrated its power to check urinary fermentation in cystitis accompanied by ammoniacal urine, even when administered internally—indeed Johnson has proven that it appears in the urine within ten minutes after its ingestion. The experiments of Kitasato show that a 2.7% solution had the power of killing typhoid bacilli after an exposure of five hours and that a 1.5% solution killed cholera spirilla in a similar length of time. Miquel places its antiseptic power as 1:143.

By virtue of its freedom from irritating properties and its exceedingly low toxic power it is of great practical value in the treatment of wounds, ulcers, abscesses, burns, inflammations of the throat and eye, and is especially valuable for continuous irrigation either in obstetrical or surgical operations; these properties make

it also very useful in the local antiseptic treatment of the newly-born.

Boracic acid may be administered internally in doses of 10–15 grains, from three to six times a day.

Bromoform. — Also termed *Tri-bromo-methane*; a compound analogous to chloroform and iodoform—this analogy is best seen by a comparison of the chemical formulæ which are as follows:

$CHBr_3$ $CHCl_3$ CHI_3

It may be prepared by the action of bromin and potassic hydroxid upon methyl alcohol or by the action of sodic hypobromite upon acetone. Bromoform is a *colorless*, clear, limpid liquid with an agreeable odor and a sweetish taste. Any coloration of the substance indicates its decomposition with a consequent liberation of bromin; such specimens should be rejected if intended for internal use. The liquid is quite heavy, being nearly three times as heavy as water and with a boiling point higher than that of the latter; it is soluble in alcohol and ether but insoluble in water. It possesses to a marked extent the antispasmodic, hypnotic and analgesic properties of the bromids (due no doubt to the bromin contained therein) but possesses also some antiseptic properties. Dr. S. Solis-Cohen reports favorable results from its use in ozena and tuberculous as well as other ulcerations of the larynx. In England success is said to have followed the use of inhalations of bromoform in the treatment of diphtheria—particularly so in recent epidemics. The drug is of special value in the treatment of pertussis (whooping cough) although

its value here is probably due more to its hypnotic and antispasmodic properties than to antiseptic activity. It has also anesthetic properties somewhat similar to those of chloroform. Usual dose 1–5 minims in alcoholic liquors or syrup of acacia or paregoric.

Bromol. — This substance, also called *Tri bromo-phenol*, is prepared by the action of bromin upon an aqueous solution of phenol and has the chemical formula $C_6H_2Br_3OH$. When pure it occurs as a white, crystalline substance with a sweetish yet astringent taste and a strong disagreeable odor like that of bromin itself. It is insoluble in water but is readily soluble in alcohol, ether, chloroform, glycerin and the fatty and ethereal oils. Bromol has been employed successfully as an intestinal disinfectant in cholera infantum and typhus fever and also as a local remedy in diphtheria.

Bromol is best used, locally, as a solution in glycerin of a strength of 1:25. Internally, especially in choleraic troubles in children, it may be given in doses of 1–12 to 1–4 of a grain.

Bromo Phenol. — This substance, which is *Ortho-bromo-phenol*, is a dull, violet-colored liquid with an odor like that of carbolic acid (phenol), of which it is a bromin derivative. According to Squibb this substance must have the chemical formula C_6Br_5OH. It is soluble in water, alcohol, ether and alkalies. Tchourilow reports, from St. Petersburg, excellent results following its use in twenty cases of erysipelas; he employed it in the form of a 1–2% ointment made by incorporation with soft paraffin. Good effects followed its use in

anthrax and tetanus experimentally produced in rabbits.

BUTYRIC ACID.—This substance is utterly devoid of germicidal power. Koch found that an immersion of anthrax spores in the acid for five days did not result in their destruction. This acid is the fourth member of the group of so called "fatty acids" and has the chemical formula C_3H_7COOH

CALCIC CHLORID.—$CaCl_2$. Highly deliquescent and freely soluble in water. Koch demonstrated that even a saturated aqueous solution of the salt is incapable of killing anthrax spores. Miquel has determined that it is antiseptic in the proportion 1:25.

CALCIC HYDROXID (LIME WATER).—$Ca(OH)_2$. Pfuhl found in experimenting upon the effect of "lime water" upon typhoid stools that 3% would sterilize them in six hours and that 9% would sterilize them in two hours. Lime water is produced by the action of water upon quick lime; Kitasato found that a solution containing .1% of quick-lime (CaO) had the power of killing the typhoid bacilli and the cholera spirilla in five hours. Jaeger made experiments with a view to determining the power of lime-washes; one application destroyed several pyogenic and pathogenic species in twenty-four hours but had no effect upon the *Bacillus tuberculosis*, even after three successive applications.

CALCIC HYPOCHLORITE ("CHLORIDE OF LIME").—$Ca(ClO)_2$. Commonly called "chloride of lime"—it is not the chlorid ($CaCl_2$) but chiefly the hypochlorite ($CaCl_2O_2$), although it does frequently contain portions

of the chlorid. It is prepared on the large scale by the action of chlorin upon calcic hydroxid or else quick-lime and is a white powder with a chlorin-like odor. When exposed to the air it becomes damp by absorption of atmospheric moisture, that is, it is hygroscopic; this absorption of moisture is accompanied however by a chemical decomposition with a gradual evolution of free chlorin, which is an active disinfectant and bleaching agent. Good "chloride of lime" should contain at least 25–30% of available chlorin. This substance is one of our best domestic germicides and is of great value—not in the treatment of wounds but in the disinfection of infected articles. In order to be effective against bacilli and spores, as found in the fecal discharges, it must be used in a 4 per cent solution containing at least 25 per cent of available chlorin, although somewhat weaker solutions will be almost as efficacious. The American Public Health Association maintains that a solution containing .25 per cent of available chlorin is an efficient germicide even when allowed to act for one or two minutes. Duggan found that .06 per cent would kill the spores of *Bacillus anthracis* and *Bacillus subtilis* in two hours. Nissen in his important experiments upon this substance with a view to determining its germicidal power demonstrated that a .12 per cent solution was able to kill typhoid bacilli and cholera spirilla in five minutes; a .1 per cent solution would kill anthrax bacilli in one minute; a 5 per cent solution would destroy anthrax spores in thirty minutes and a 1 per cent solu-

tion would produce the same result in seventy minutes. He also determined that .5–1 per cent would destroy the germs of cholera and typhoid, in feces, in ten minutes. Certainly it seems to be the disinfectant *par excellence* for sterilization of infectious stools and other discharges.

Calcium Salicylate.—$CaC_7H_4O_3 .H_2O$. This substance occurrs as a white, tasteless, odorless and crystalline powder not readily soluble in water. It is said to be especially valuable in such intestinal disorders of children as diarrhea and gastro-enteritis. It is usually administered in doses of 8–24 grains.

Camphor (Laurinol).—$C_{10}H_{16}O$. A gummy substance obtained from the *Laurus camphora* which is indigenous to the eastern portion of Asia. It is a volatile solid which occurs in white, translucent masses of a tough consistency and a crystalline structure. It has a characteristic penetrating odor and toxic properties. It is nearly entirely insoluble in water but is soluble in alcohol, ether and chloroform. The experiments of Arloing, Thomas, Cornevin, Cadeac and Meunier demonstrate that camphor has little if any germicidal power. It required from eight to ten days to kill the spirilla of cholera and the bacilli of typhoid fever, which germs are by no means highly resistant.

Carbolic Acid (Phenol).—Also termed *Phenyl alcohol, Phenyl hydroxid, Phenyl hydrate, Hydroxylbenzene.* C_6H_5OH. Crude carbolic acid is a reddish-brown neutral (not acid) liquid with a strong empyreumatic and disagreeable odor. It is obtained by the distilla-

tion of coal tar and contains phenol, cresol and other substances. The pure acid is obtained by the fractional distillation of the crude product and occurs either in the form of colorless acicular crystals or else in crystalline masses produced by the interlacing of such crystals. It is usually colorless when pure but becomes faintly pinkish upon keeping or upon exposure; it has a characteristic aromatic odor, which in the imperfectly purified grades is like that of creosote. Carbolic acid is deliquescent—indeed the very best acid to be obtained in the market contains from two to four per cent of water and even very good acids may contain more than this. When exposed freely it forms an oily liquid, due to the absorption of atmospheric moisture. When diluted it has a sweetish taste followed by a burning and caustic sensation. It produces a benumbing effect when placed in contact with the living tissues and hence is used, either free or combined, for the production of local anesthesia. It is also caustic in strong solutions.

Carbolic acid is freely soluble in alcohol, glycerin, benzene, ether, chloroform, carbon di sulphid, the volatile oils, the fixed oils and also to some extent in aqueous solutions of the alkalies. It is generally stated, even by many so-called authorities upon the subject, that the acid is soluble in twenty parts of water only, but this is untrue, for Allen has found it to dissolve in 10.7 parts by weight of water for one part of absolute acid—making its solubility nearly twice as great as that ordinarly given. The acid has also the power of dissolving about 27% of water, as Allen has also deter-

mined, and not 5% as usually given. With elevation of temperature a larger proportion of water can be held in solution, becoming turbid upon cooling. When 5% of water has been absorbed it becomes permently liquid and the acid is usually dispensed in this condition.

By far the greatest use of carbolic acid, or phenol, in medicine is as an antiseptic and germicide. The antiseptic and disinfectant properties of coal-tar were recognized by Chaumette as early as the year 1815. These valuable propertise were recognized and their existence in coal tar confirmed by Guibourt (1833), Siret (1839), Bayard (1846), Le Boeuf (1850), Calvert (1857), Lemaire (1860) and Dumas. Dumas called attention to the fact that carbolic acid existed in coal-tar and to it was probably due its antiseptic virtues. Lemaire experimented with coal-tar saponine and also carbolic acid—in 1863 appeared his little work "*De l'acide phenique*," which created such wide-spread interest. Since that time the manufacture of carbolic acid became an industry. Lemaire was the first to use carbolic acid to any extent and was among those who early recognized the truth of the germ theory as applied to wounds and wound complications—he was, as someone has said, "an advanced treater of wounds with antiseptics, nothing more." But really what more could one want or demand at this early stage, before the birth of systematic antiseptic methods? Carbolic acid was also the first antiseptic agent made use of by Lister; it is one of the oldest and best studied of all antiseptics—indeed to this very drug is due the credit

of opening and founding the new era in surgery.

Hare ranks carbolic acid next in importance and efficiency to mercuric chlorid (corrosive sublimate) which he places first as an antiseptic and germicide. He calls special attention to the fact that it is equally valuable in albuminous and non-albuminous solutions, which is not true of mercuric chlorid. Carbolic acid is a reliable antiseptic in comparatively weak solutions, such as 1:20, and even 1:40 may be depended upon. Its complete admixture with all of the secretions allow of its complete penetration into all parts of a wound surface and thereby thorough disinfection is obtained. Carbolic acid also possesses the advantage of not being neutralized by the substances found in the excreta or by the presence of albumin, although it causes coagulation of the latter. Bolton found that the addition of 10 per cent of albumin to a bouillon culture did not materially influence the action of the carbolic acid thereon. Even Koch, who advocated corrosive sublimate so strongly at one time, says that carbolic acid affords an excellent means of destruction for a certain category of micro organisms, indeed a very great number. While carbolic acid or phenol is of undoubted value as an antiseptic and germicide yet its compounds, of which there are hundreds, are all inferior to carbolic acid itself, according to Koch.

The antiseptic virtues of the acid have been indubitably proven by numerous experiments. Cheyne found that if milk was poured from one vessel to another within the influence of the carbolic spray and then se-

curely sealed that it would remain unchanged for at least two months. Grace Calvert (1870) found that albumen was preserved by admixture with carbolic acid. Dougall found that a solution of the strength of 1:2,500 was sufficient to destroy not only spermatozoa but also the higher infusoria. Schroeter (1878) found that a solution of 1:2,000 was sufficient to preserve flesh four weeks and that a strength of .2% (1:500) preserved it permanently. Hoppe-Seyler and Baxter determined that a 2% solution the acid destroyed the infective power of vaccine with certainty; this was also corroborated by many others. The germicidal power of the drug has been studied by Calvert, Dougall, Schroeter, Baxter, Sternberg, Hoppe-Seyler, Hugge, Koch, Rosenbach, Davaine, Blythe, Arloing, Cornevin, Thomas and others upon almost all known forms of organisms. Many of these investigators claim that an aqueous solution of 1% is sufficient to destroy the infective power of ordinary septic and purulent matters and that 2% will destroy the infectious principle of vaccine and glanders. Miquel has determined that it is antiseptic in the proportion of 1:333 but the experience of Dougall, Schroeter and others seem to indicate that this is far too low a power to assign to it.

Koch found that in the absence of spores a 1% solution was sufficient to quickly destroy bacteria, but that anthrax *spores* require at least 3 per cent in order to obtain this result and 5 per cent in some cases. The experiments of La Place however indicate that the addition of hydrochloric acid materially increases the germ-

icidal power for spores. Yersin found that 1 per cent would destroy the tubercle bacillus in one minute while 5 per cent would do this in *thirty seconds.* Nicati and Rietsch determined that .5 per cent (1:200) would kill cholera spirilla in ten minutes. Schill and Fischer found that a 3 per cent solution was sufficient to destroy the infectious power of tuberculous sputa, but that a 5 per cent solution was required to destroy pure cultures.

Davaine determined that 1 per cent would destroy anthrax bacilli in fresh blood in one hour. Sternberg found that 1:125 solutions destroyed pus cocci and 1:200 solutions destroyed the *Micrococcus Pasteuri* in two hours. It is interesting to note that Koch has prov en that solutions in oil or alcohol are much less efficient than aqueous solutions. Bolton proved by two hours action upon fresh bouillon cultures that a 1 per cent solution would destroy the bacilli of typhoid fever, the spirilla of cholera, the bacteria of green pus and *Staphy lococcus pyogenes albus*, *aureus* and *citrus* and *Streptococcus pyogenes* (the pus cocci causing putrefaction, the chief foes of the surgeon). The experiments of Douglass and Baxter led them to the conclusion that aerial disinfec· tion by carbolic acid was practically impossible. Stim· son corroborated these results as far as the use of the spray for this purpose is concerned.

It is clear then that to be effective as germicides solutions must have a strength of at least 1:40. The two chief objections which have been raised against the use of carbolic acid in wounds are (*a*) the oozing which its use seems to cause, and (*b*) its caustic or irritating

properties which are not great. Attempts have been made to meet these objections in several ways; the methods which seem to give more promise of success than all others are those in which the acid is combined with something else in the form of a powder which is not only absorbent but which also, either by direct union with the acid or else by its own peculiar soothing and emollient effect, robs the acid of its irritant properties, slight as they are.

At the German Congress of Medicine, held at Wiesbaden, April 12–15, 1393, Professor von Ziemssen reported very satisfactory results from the use of injections of 1–2 c.c. (about eight minims) of a 2 per cent solution of carbolic acid into the substance of the tonsil in many cases of catarrhal inflammation of the throat. The temperature fell almost immediately, and in every case recovery took place rapidly. The same method of treatment was also successful, though less constantly, in diphtheria, where its effects, however, were less rapid. In a case of scarlet fever of a grave character, complicated with erysipelas, which caused a considerable rise of temperature, the desired result was obtained with two injections. It a late issue of his "Ephemeris" Squibb says: "Carbolic acid still holds prominence over its many and increasing rivals. * * * During the past year a new series of derivatives of this acid has been produced from essential oils, and patented in Germany, which claim to be odorless, tasteless, neutral in reaction and to cause no irritation. These derivatives when obtainable will have to be closely studied therapeutically."

It is of the very greatest interest in this connection to note how history repeats itself; carbolic acid was among the first of antiseptic substances introduced into common practice. For a period of time recently corrosive sublimate has enjoyed the confidence of practitioners of antiseptic surgery. Since the time when he first announced his principles Sir Joseph Lister has been working unceasingly in a search for the ideal and perfect antiseptic; many were devised only to be cast aside. Carbolic acid has received renewed prominence over its great rival, mercuric chlorid (corrosive sublimate), by the renewed allegiance of its original promoter, Lister. In his "Address on the Antiseptic Management of Wounds," delivered in the London Post Graduate Course, at King's College Hospital, on January 18, last (*Brit. Med. Journ.*, Vol. I., 1893, p. 161), he declared his complete and unqualified abandonment of corrosive sublimate in favor of his first choice, carbolic acid. The strength which he now adopts is 1:20, which he declares to be completely trustworthy for surgical purposes. Its greater efficiency as a germicide is not only established, but he also finds it greatly to be preferred in other respects. He furthermore said:

"Carbolic acid has a powerful affinity for the epidermis, penetrating deeply into its substance; and it mingles with fatty materials in any proportion. Corrosive sublimate solution, on the other hand, cannot penetrate in the slightest degree into anything greasy and therefore as the skin is greasy, those who use corrosive sublimate require elaborate precautions in the way of

cleansing the skin—treating it with oil of turpentine or ether, not to mention soap or water, to remove the grease which they feel it essential to get rid of for the efficient action of the corrosive sublimate. Now all this is unnecessary care if you use carbolic lotion. I can testify to this from very ample experience. For my part I do not even use soap and water. I trust to the carbolic acid, which, by its penetrating power and great affinity for organic substances, purifies the integument in a way that inorganic salts, like corrosive sublimate, cannot." This renewed allegiance of Lister's, coming as it does at a time when the investigations at the Johns Hopkins University and the University of Michigan cast considerable doubt upon the existence of the high degree of activity which has usually been ascribed to corrosive sublimate, has a peculiarly weighty significance.

Carvacrol.—A substance, said to be a phenol, occurring in the essential oil of several plants of the species *Origanum*. Its chemical composition is $C_{12}H_{14}O$. It is a thick oily body, its iodid being a yellowish-brown powder. The salt is insoluble in water but freely soluble in ether, chloroform and olive oil. It has been used locally, in the form of powder, ointment and as gauze, as an antiseptic in diseases of the skin and as a substitute for iodoform in the treatment of wounds and ulcerations.

Chinoline (Quinoline) —C_9H_7N. A substance obtained from chinonine or quinine by distillation; it may be also synthetically prepared. It is, when pure, a

colorless liquid with a characteristic, pungent and aromatic odor. It is almost insoluble in cold water but freely soluble in alcohol, ether and hot water. It has been mainly used as an antiseptic. It is used locally as a 10% solution in rectified spirit or else peppermint water Internally the dose of chinoline itself is 3–10 minims; of the tartrate, 5–15 grains.

CHLORAL (TRI-CHLORALDEHYD). — Sternberg found that a 20% solution required two hours to kill pus cocci. Miquel has determined that it is antiseptic in the proportion 1:107. Evidently it possesses no great germicidal power. Chemical formula, CCl_3COH; the hydrate, $CCl_3CH(OH)_2$ or better $CCl_3.COH.H_2O$.

The antiseptic properties of chloral were first noticed by Hirne and Dujardin-Beaumetz in 1872. The subject has been also investigated by Keen and Personne. It has been shown, as Wood says, that a solution of twenty to forty grains to the ounce will preserve animal tissues for a great while, probably indefinitely. Even the finest microscopical structure appears to remain uninjured by this strength. In his first experiences with the drug, Dr. Keen hoped that as long as it does not affect the color of the tissues it might prove useful in the dissecting room; subsequent trials have confirmed this. Dr. Keen has also found the drug efficient in keeping the urinals of paraplegics and others suffering from incontinence of the urine free from the objectionable odor. However the drug has no great germicidal power.

CHLORIN.—Chemical symbol, Cl. Chlorin is a gas,

officinal in aqueous solution. The value of chlorin and its compounds as disinfectants have been known ever since their discovery in the latter part of the last century (1774). Indeed all of the haloid elements have distinct germicidal properties. Guyton, as early as 1795, recommended the use of chlorin by fumigation. When brought into contact with organic substances in the presence of moisture chlorin unites with the hydrogen of the water thus:

$$H_2O+Cl_2=2HCl+O$$

and liberates *nascent* oxygen, which has marked antiseptic properties. Hence its action is due not to direct action of chlorin itself but to its strong affinity for hydrogen and the nascent oxygen formed by its union with the hydrogen of water. In this same way it has the power of deodorizing and destroying sulphuretted hydrogen, which is generated by the decomposition of albuminous bodies, such as eggs. The germicidal power cf chlorin is very great, much more so, in fact almost entirely so, in the presence of moisture for the reasons above given. In the presence of moisture however it bleaches as well as disinfects. Fisher and Proskauer found that dried anthrax spores exposed for one hour to an atmosphere (dry) containing 44.7% of dry chlorin gas were not destroyed. In the presence of moisture one hour's exposure to an atmosphere containing only 4% of chlorin gas was sufficient to effect their destruction—indeed even 1 per cent produced this result in the presence of moisture if the exposure was prolonged to three hours. The experiments of Fisher,

Proskauer, Koch, Sternberg, De la Croix and others indicate that the germicidal power of the gas is very great in the presence of moisture, otherwise it is almost *nil.* Rohe thus sums up our knowledge of chlorin:

1 Chlorin is an efficient disinfectant when present in the proportion of one part in one hundred; provided the air and the objects to be disinfected are in a moist state and the exposure continues for upwards of an hour.

2. Chlorin, when used in sufficient concentration to to act as a trustworthy disinfectant, injures colored fabrics and wearing apparel.

3. The use of chlorin, and in a greater degree of bromin, requires considerable experience in management; when carelessly handled they may cause inconvenient or even dangerous symptoms in persons using them; for these reasons they are not suitable as disinfectants for popular use.

These same remarks also appertain to the other members of the halogen group of chemical elements, such as iodin and bromin.

Neither chlorin in substance nor in aqueous solution are used to any great extent in internal medication; although some experimenters have used it empirically as an inhalation in the treatment of certain infectious diseases of the pulmonary tract, more especially pulmonary tuberculosis. Vaporized iodin has also been used in the same manner in the same class of diseases. By far the most efficacious disinfectant of all of the chlorine compounds in common use is the so called "Chloride of Lime".

Chloroform (Tri chlor methane).—This substance has the chemical formula $CHCl_3$. Its chemical and physical properties are too familiar to physicians to need further discussion or description.

Kirchner found that 1 per cent killed cholera spirilla in less than one minute while typhoid bacilli required exposure for at least an hour to the influence of 1–2 per cent (5 per cent) to effect the same result. In the experiments of Salkowski it was determined that, in the absence of spores, anthrax bacilli and cholera spirilla were killed in half an hour by exposure to the drug. Koch found that anthrax spores, however, did not have their vitality destroyed even by one hundred days' immersion in chloroform. Evidently then the action of the drug, as a germicide, is directed to the parent cells and seems to have little or no effect upon spores—at least those of the more resistant germs.

Chloro-phenol (Tri chlor-phenol).—This substance is a derivative of phenol (carbolic acid) in which three atoms of hydrogen are replaced by three atoms of chlorin and hence it has the chemical formula $C_6H_2Cl_3.OH$. It occurs in the form of colorless, needle-like crystals with an odor of phenol, which is more strongly marked than in its allied substitution product called *Bromo phenol* and which it remarkably resembles in solubility as well as properties.

Chlorphenol (Mono chlor phenol).—This substance is phenol in which one of the hydrogen atoms of the phenyl (C_6H_5) is replaced by one atom of chlorin, thus $C_6H_4Cl.OH$. It occurs as a volatile

liquid heavier than water and possesses antiseptic properties. It is said to have been employed with good results in tuberculous diseases, bronchitis, laryngitis, ozena, discharging glands, ulcers and wounds. It is usually administered by inhalation but is also employed as a local application.

Chromic Acid.—This substance has the chemical formula H_2CrO_4. It is obtained by the treatment of potassic di-chromate with sulphuric acid and by dissolving the resulting long, red, hygroscopic, rhombic prisms of needles of chromic anhydrid (CrO_3) in water. It mixes with water in almost all proportions. The substance is employed in concentrated solutions as a powerful caustic in the treatment of tumors, excrescences, syphilitic tumors or ulcers, etc. It can be used in various strengths, such as 1–5 per cent. It is often used for sterilizing and hardening various surgical preparations. In ozena and gonorrhea, aqueous solutions of the drug in the strength 1:1000 have been used. As antiseptics chromic and osmic acids are of about equal values. Koch's experiments indicate that it is markedly germicidal, a 1 per cent solutión destroying anthrax *spores* in one to two days. Miquel has determined that it is antiseptic in the proportion 1:5000. Its chief objection is the fact that it is exceedingly irritating and caustic, indeed cases are reported in which death has been ascribed to its free use.

Chrysarobin.—$C_{30}H_{26}O_7$. Obtained from the wood of the tree, *Andira araroba*. The drug occurs in orange-yellow or golden, shining, tasteless needles which are

soluble in alcohol, ether, chloroform, benzene, alkaline and acid solutions and slightly so in water. It is chiefly used as anti-parasitic in the treatment of various affections of the skin and is said to have given especially good results in psoriasis. Externally it is applied usually in the form of an ointment of 10 per cent strength. Internally the dose is from 1–8 to 1–4 of a grain. Its internal use is however comparatively restricted and seldom resorted to.

Citric Acid.—$H_3C_6H_5O_7.H_2O$. Citric acid is a tribasic organic acid found in the juices of many fruits such as the strawberry, raspberry, currant, cherry, etc., but especially in the lemon, from which fact it receives its name. It occurs in the form of colorless crystals which are readily soluble in water. Van Ermengem determined experimentally that .5 per cent (1:200) was sufficient to kill cholera spirilla in half an hour. Kitasato found that .43 per cent killed typhoid bacilli in five hours and .3 per cent would kill the cholera germ in the same time. Clearly then the substance possesses germicidal powers which are very manifest in the case of the less resistant germs at least.

Coffee Infusion.—The experiments of Heim and Luederitz indicate that this substance possesses antiseptic and feeble germicidal power. To what ingredient this was due they did not determine but agreed that it was not dependent upon the caffein.

Corrosive Sublimate (Bi-Chloride of Mercury, Mercuric Chlorid).—$HgCl_2$. This substance occurs as a heavy white powder or in colorless, rhombic crys-

tals or else in crystalline masses; it crystallizes from concentrated solutions in hot water in the form of acicular or needle-like crystals. When heated it fuses. It has an acrid, metallic taste and an acid reaction and is strongly poisonous and antiseptic. Is used chiefly in medicine as an antiseptic or else in the internal treatment of syphilis. It is soluble in cold water and glycerin but much more so in hot water, alcohol and ether.

Up till the year 1881 the favorite and indeed almost universal antiseptic was carbolic acid; but in that year Koch announced his belief in the superior efficacy of mercuric chlorid and the tide of popular favor surged largely in the direction of the latter drug. This action was based upon experimental evidence which seemed to indubitably demonstrate the superior germicidal power of the mercurial salt. For instance it was stated that a 1:300,000 solution would restrain the growth of anthrax *spores* while a 1:1,000 solution would destroy them. Indeed most of the authorities of the surgical world seemed convinced by the evidence brought to bear in favor of mercuric chlorid. Sternberg said that the experimental data indicated that its use for disinfection in strengths of 1:500–1:1,000 was reliable for material containing spores and in the strength of 1:2,000–1:5,000 for pathogenic bacteria in the absence of spores, but that due regard must be had for the fact that the presence of albumin very materially reduces its germicidal potency. We now know, however, that even the very strongest solution (1:500) which he gave is not able to *destroy* pus cocci and other micro-organisms, *even in the*

absence of spores. We know now that its action is that of inhibition and not destruction. In the year 1883 Sternberg gave the following table of the relative values of various germicidal, or supposed germicidal, agents:

EFFICIENT.

Mercuric chlorid	1:20,000.
Potassic permanganate . . .	1:833.
Iodin	1:500.
Creosote	1:200.
Sulphuric acid	1:200.
Carbolic acid	1:100.
Hydrochloric acid	1:100.
Zinc chlorid	1:50.
Tr. of Ferric chlorid	1:25.
Salicylic acid . . . . . . (Dissolved with borax).	1:25.
Potassic hydroxid	1:10.
Citric acid	1:8.
Chloral hydrate	1:5.

FAILED

	PER CENT.
Fowler's solution	40.
Sodic "hyposulphite"	32.
Sodic sulphite (exsic.)	10.
Ferric (?) sulphate . . . . (Ferr*ous* is probably meant).	10.

Potassic iodid	8.
Zinc chlorid (liquid)	8.
Zinc sulphate	20.
Boracic acid (sat. sol.)	4.
Sodic borate (sat. sol.)	4.
Sodic salicylate	4.

In these experiments of Sternberg the micrococci of pus were used and further experimentation conducted with the micrococci of septicemia, the *Bacterium termo* and the bacte:ia of "broken-down beef tea" indicated that their relative values as germicides remained practically the same.

For a long time it (mercuric chlorid) was considered one of the very best of all germicides.

Even Koch in his advocacy of corrosive sublimate said that while solutions of 1:10,000, 1:20,000 or even 1:30,000 exert an inhibitory and sometimes toxic action upon germs and spores when brought into direct contact with them, a much stronger solution is required for prompt destruction. In some cases the results obtained where wholly negative; thus, fresh tubercular sputum remained infectious even after an exposure *for twenty-four hours* to a solution of a strength of 1:2,000. Moreover the substance is exceedingly prone to decompose in the presence of albumin, chemically combining with it and thereby losing much of its antiseptic activity and also rendering it difficult to forecast the certainty and extent of its action when such conditions obtain.

Recent investigations conducted at the Johns Hop-

kins University and at the University of Michigan have shown that solutions of mercuric chlorid, when used as germicides, are often inert and still oftener actually injurious to the tissues when applied in surgical operations. A long series of experiments at the Johns Hopkins Hospital resulted in defining the limitations of the drug as follows:

1. Under the most favorable conditions, a given amount of sublimate has the power of rendering inert only a limited number of individual organisms. (It does not *destroy* them).

2. The disinfecting activity of the sublimate against organisms is profoundly influenced by the proportion of albuminous material contained in the medium in which the bacteria are present.

Kelly, Robb and Ghriskey, as well as others, have proven that even strong solutions (such as 1:500) while antiseptic and inhibitory are devoid of any *germicidal* power. Kelly says: "Corrosive sublimate solutions as strong as 1:500 are *not germicidal* after immersion of the hands from two to five minutes. The mercury salt acts either by mechanically coating or chemically combining with some portion of the coccus, thus only inhibiting further growth *until the salt is precipitated or removed.* This I have repeatedly shown to be true following both the ordinary practice of immersion of the hands from two to five minutes in 1:500 and 1:1,000 solutions after a preliminary washing for ten minutes with soap and water, and again after carefully following out Fuerbringer's method, now so generally adopted.

The latter method was distinctly shown to be inefficient in almost every instance." After considerable research upon the subject he furthermore decides that corrosive sublimate, although dangerous on wounds on account of the property of coagulating and causing necrosis of the albuminous tissues, yet has the valuable property of inhibiting, not destroying, the action of those germs with which it comes in contact. Indeed Halsted has shown that the irrigation of fresh wounds by a solution of corrosive sublimate *as weak as 10,000* is followed by a distinct line of superficial necrosis which is clearly demonstrable under the microscope. Then also, its distinct toxic properties must not be forgotten for an instant; especially is this the case when the substance is to be used in intra-uterine or vaginal injection, or in the serous cavities, or in irrigation in surgical operations.

The *quondam* virtues of corrosive sublimate were founded primarily upon the dicta of Koch and other experimenters. It remained for the present decade to demonstrate the faulty conditions underlying these primary experiments upon which the reputation of the drug was founded and to show that the extravagantly high value placed upon the substance, as a direct result of such experimentation, was also faulty, not to say false. Clinical experience has demonstratad that corrosive sublimate does possess inhibitory power in a high degree, but modern bacteriological research has just as clearly demonstrated that such power is purely inhibitory and not at all germicidal in nature. Not only is

its action purely inhibitory but even this action is influenced to a great degree by the conditions surrounding the application. Indeed the differences in power of corrosive sublimate under different conditions are very much greater than those of carbolic acid,—or most of the other germicides in fact. Aside from the presence of oily materials, which are distinct checks to the efficiency of corrosive sublimate, the greatest obstacle against its use in the animal tissues and fluids is the fact of its precipitation by and with albuminous substances. So great are the dimensions of these obstacles that many claim that it may be seriously doubted whether it is possible to thoroughly disinfect, with corrosive sublimate, wounds infected with bacteria. It is also doubted whether irrigation with solutions of corrosive sublimate is able to accomplish much more in the way of disinfection than is obtained by the use of *sterile solutions of common salt.*

It is chiefly and especially to Geppert that we owe the demonstration that the former methods of testing and ascertaining the germicidal power of mercuric chlorid were subject to such very grave errors that the results obtained therefrom were entirely untrustworthy and far from reliable. It was formerly claimed that mercuric chlorid had the power of absolutely destroying bacteria. Geppert has shown that in order to prove this not only must the germ be subjected to the action of the substance but at the termination of the exposure the antiseptic must be *thoroughly removed* from the germ; if such removal is not thorough even a slight remaining

amount of the antiseptic may be sufficient to inhibit future development and the erroneous conclusion reached that the germ is dead because it does not develop. Geppert has also shown that the best means of ridding the germ of the sublimate is the precipitation of the mercurial salt by means of ammonic sulphid, or any other alkaline sulphid, in order to determine whether bacteria which have been originally subjected to the action of the sublimate have been destroyed or not. When this precaution of precipitation is taken it is found that corrosive sublimate (mercuric chlorid) is far less energetic than has been generally supposed. Thus Koch believed that from his experiments he had demonstrated that corrosive sublimate in the strength 1:1,000 destroyed anthrax spores in one minute. Geppert has shown, however, that the same strength may not have killed all of the spores in watery suspension, *even at the end of three days!* Indeed in a recent article he has even shown that it is exceedingly difficult to determine with any degree of accuracy whether all of the spores are destroyed by the sublimate or not; for a definite concentration of the reagent (the sulphid) used for such precipitation is required in order to effect a complete separation of the sublimate from the germ. Hence neither failure to obtain cultures after such precipitation, nor failure of cultures, so treated, to infect an animal are proof that the germs or spores have been killed by sublimate; for a different concentration or strength of the substance used to precipitate the sublimate, or else the use of some reagent *less injurious, per se*, to the

spores or germs might show that they possessed still greater resistance to the action of the sublimate, as Welch has also stated. This is exceedingly plausible when we remember that definite concentrations of the alkaline sulphids must possess some antiseptic virtues and these but reinforce the action of the sublimate, as far as the action upon the germ is concerned, although resulting in the ultimate precipitation of that compound.

Abbott has also confirmed several of these results. His recent experiences (1891) show that 1:1,000 does not always destroy *Staphylococcus pyogenes aureus*, even after five minutes exposure—in some cases requiring as much as ten, twenty or even thirty minutes to in hibit their action. In his experience the cyanid and iodid are both of higher inhibitory power—although the first is exceedingly poisonous.

In 1884 Professor Klein made the curious statement that corrosive sublimate has no more germicidal power than vinegar—such vinegar, containing from 6.3 to 7.0 per cent of acetic acid, prevented the growth and devel opment of micro organisms just as effectually as a 1:1,000 solution of the sublimate. McClintock, of the University of Michigan made elaborate experiments with a view to testing such statements of Klein. His results strongly corroborated those obtained by Klein, Geppert, Welch, Kelly, Robb, Ghriskey and others, confirming the statement that the actual *germicide* value of corrosive sublimate is very low. Lister distinctly states that it is, as a germicide, far inferior to carbolic acid. McClintock made exhaustive experi-

ments with various germs, using solutions of corrosive sublimate as the inhibitory agent. His results show that it is possible for germs to withstand the action of that drug as follows:

Staphylococcus pyogenes aureus:

1:1000—23 hours. 1:100—11 hours.

Saturated solution for one hour!

Bacillus subtilis:

1:1000—41 hours.

Saturated solution for eighty-five minutes!

The germ of Swine Plague:

1:200—1 hour.

Typhoid bacillus:

1:1000—1 hour.

Germs in Feces:

1:1000—24 hours.

Saturated solution for twenty four hours!

These results fall with astounding effect upon him who sees naught save perfection in corrosive sublimate; they come home with telling force to Ephraim "who is wedded to his idols."

We may consider it conclusively proven that corrosive sublimate has comparatively low germicidal power although high in inhibitory activity. In using it we must be mindful of the following facts:

1. It is exceedingly poisonous, even in small quantities.

2. It corrodes all of the common metals, depositing upon them a thin film of metallic mercury.

3. It causes superficial necrosis when brought into

contact with living tissue, even in solutions as weak as 1:10,000.

4. It unites with albuminous substances with great facility, forming an isoluble and inert (while insoluble) compound. Lister has suggested that the albuminate of mercury thus formed has antiseptic properties if rendered soluble. Laplace recommends the combination of tartaric acid with the sublimate to overcome this tendency to decompose or to combine with albumin. Others have recommended the combination of common salt or of ammonic chlorid for this same purpose.

5. It does not owe its virtue to the fact that the germ is destroyed, as is commonly believed, but simply to the fact that it prevents development of the germ *while it is present*.

6. The substance when left in contact with organic matter, such as sponges or dressings, especially in the presence of light or heat, is prone to decompose—becoming thus inert.

Creolin (Liquor Antisepticus).—This substance is a form of *Cresol* obtained by the dry distillation of English coal. It is said to be a coal-tar product resembling carbolic acid in appearance but with an odor of tar. It appears as a black alkaline fluid of the consistency of syrup and a specific gravity slightly higher than that of water. Its odor is characteristic. It is soluble in alcohol, ether and chloroform and insoluble in methyl alcohol and water—with the latter it forms an opaque emulsion, on this account it can never supersede carbolic acid for the sterilization of instruments and the main-

tenance of an aseptic condition of such instruments during a surgical operation. It undoubtedly possesses decided germicidal power but is inferior in its action upon pathogenic organisms to carbolic acid—except in the case of the spirilla of cholera. It has by no means developed the high germicidal power at first claimed for it. It is a cheap and efficient germicide but is decidedly inferior to carbolic acid—especially in the presence of albumin, its efficiency being almost neutralized by the occurrence of as small a proportion of albumin as one part in one hundred. It is highly extrolled by Neudoerfer who says that it is "absolutely non-toxic to man; is ten times more germicidal than carbolic acid; is soluble in water, alcohol and glycerin; it controls hemorrhage and pain; it limits suppuration; it injures neither metal nor hands; it is very cheap." He not only enlarges upon its advantages, giving the substance properties which it never possessed, but he neglects to give its disadvantages. In the first place, it is not "absolutely non-toxic," this has been disproven by experience—Martin distinctly says that it is not only toxic but that it causes nausea, vomiting and albuminuria. In the second place, it is not as efficient, all in all, as carbolic acid. In the third place, it is not only insoluble in water but forms a non-transparent emulsion with that substance. Moreover its odor is decidedly unpleasant and the compound itself is unstable.

It has been previously stated to be a coal-tar product but is reported by Dr. F. Raschig to be nothing more nor less than a mixture containing about one part of

resin soap with two parts of crude carbolic acid of about twenty per cent strength, although its manufacturers claim that it is entirely free from carbolic acid. Squibb says that its action as a disinfectant reminds one strongly of carbolic acid. He also says that unfavorable results have also been presented in regard to its use.

Creosotal.—A short name recently adopted for the so called carbonate of creosote, which is supposed to result from the union of creosote and cardon-di oxid. At ordinary temperatures it is an oily, amber-colored liquid, becoming more fluid upon warming it. It is neutral to litmus, odorless and with a faint sweetish taste of creosote. It is insoluble in water, dilute alcohol and glycerin, but readily soluble in alcohol, ether, chloroform and benzine. It is claimed that the substance contains ninety per cent of creosote and is yet free from all of the disagreeable properties of the latter drug. It is recommended in doses of $\frac{1}{4}$ to 1 drachm daily, increasing to one and a half drachms or even as high as half an ounce. It is recommended especially of in tuberculous affections of the lungs, or indeed in any condition where creosote itself is applicable.

Creosote.—This substance is a product of the distillation of wood tar and resembles carbolic acid in many of its properties, more especially those of an antiseptic nature. It consists chiefly of a mixture of substances, such as creosol ($C_8H_{10}O_2$) and cresol (C_7H_8O) which are members of the phenol series. The creosote prepared from beech wood is chiefly recommended for internal administration where so used. Fully ninety

per cent of the substance dispensed as "pure beechwood creosote" in drug stores is naught else than carbolic acid. The latter is eliminated chiefly by the kidneys, giving the characteristic color to urine, while creosote is supposed to be eliminated, in part at least, by the lungs.

Sternberg in his experiments upon the substance in order to determine its germicidal activity found that 1:200 was fatal to micrococci. Guttman found that it was antiseptic in its action upon pathogenic organisms in solutions as weak as 1:3000 or 1:4000, but that in such proportions it did not necessarily kill the organism. Schill and Fisher demonstrated that 1 per cent failed, even after twenty hours exposure, to destroy the *Bacillus tuberculosis* in tuberculous sputa. Yersin's experiments were somewhat confirmatory, he found that a saturated aqueous solution did not destroy the tubercle bacillus in twelve hours.

Cresin:—Sometimes also spelled *Kresin.* Crude carbolic acid consists of a mixture of cresols or phenols and would be of great antiseptic value but they are almost insoluble in water and according to Laplace are almost worthless as disinfectants on that account. In order to meet this objection Cresin, which is a solution of cresol (25%) in an equal amount of Sodic Cres-oxyl-acetate, was prepared. It is a brown liquid, said to be entirely free from carbolic acid and with an odor of Cresol and forming a clear neutral solution when mixed with water. It is said to possess antiseptic properties. It is recommended for local use in solutions of strengths

of from $\frac{1}{4}$ to 1 per cent. It has not as yet been recommended for internal use. Its chemical formula is C_6H_4. CH_3. OCH_3. COOH.

CRESOL.—The cresols, as Squibb says, are still used as disinfectants, but their disadvantages are of such a nature that they continue to retard their utility. The so-called "Cresol-saponate" is now recommended by German practitioners. It is prepared by mixing crude carbolic acid with melted soft soap in equal proportions to form finally a homogeneous mass which is soluble in water. This however but increases the objectionable quality inherent in all of the compounds of cresol, namely that of rendering the surgeon's hands and instruments disagreeably and dangerously slippery.

As ordinarily found cresol is a dark reddish-brown liquid which is transparent and rather thinner than creolin. It has the characteristic odor of tar and forms, like creolin, an objectionable and opaque emulsion with water. Behring, after a very elaborate series of experiments with the substance, concludes that it certainly has no advantage over carbolic acid.

CRESOL IODID.—This substance, also called *Ortho-cresol iodid*, is another of the innumerable proposed substitutes for iodoform. It is a fine pale-yellow powder with a pronounced odor, which is agreeable in comparison with that of iodoform however; the drug is insoluble in water. The compound has not been in use long enough to give it any positive status. As Squibb says, though the compounds of cresol possess antiseptic power they all have the disadvantage of adhering to and ren-

dering the hands and instruments extremely slippery; they also readily oxidize in the atmosphere. These disadvantages apply to all of the various compounds of cresol thus far known, such as lysol, saprol, solutol, solveol, and others.

CRESYLIC ACID.—The article usually sold as cresylic acid is commonly a substance of variable composition containing various cresols and also sometimes xylenols. Whatever antiseptic power it may possess is due entirely to these substances which it contains.

CUPRIC CHLORID.—$CuCl_2$. This substance is not in general use as an antiseptic but Miquel has determined that it is antiseptic in the proportion 1:1,428. This gives it higher power than the sulphate, which is better known.

CUPRIC SULPHATE.—$CuSO_4$. The sulphate of copper is better known than the chlorid although its antiseptic properties are not as high as those of the latter compound. Miquel has determined that the sulphate is antiseptic in the proportion 1:11. Its action is decidedly inhibited by the presence of albumin.

DERMATOL.—This term is applied to the *Sub gallate of bismuth;* it contains about 55 per cent of the oxid of bismuth. It is usually represented by the chemical formula,—$BiC_7H_7O_7$. It is an odorless, yellow, saffron-like and non-hygroscopic powder insoluble in the ordinary solvents. Colasanti has made comparative bacteriological experiments with aristol, iodoform and dermatol in order to determine their relative germicidal potency. None of these agents seemed to affect dried

cultures even after three days contact; but when moisture was present dermatol was effective in little more than half the time required by the other two. It also possesses remarkable dessicating powers although its antiseptic powers are in dispute in many quarters. It is chiefly used as a substitute for iodoform. It may be applied locally as a dusting powder, on gauze, in glycerin, collodion emulsion or in ointment in the strength of 10–20 per cent. It has been used internally with good results in disorders of the gastro-intestinal tract, as a substitute for the sub-nitrate of bismuth. Flint reports good results from such uses.

DIAPTHERIN.—$(OH.C_9H_6N_2)$ (OH) (SO_3H) C_6H_4. Also called *Oxy chin aseptol.* It occurs as a whitish or yellowish powder with an odor somewhat like that of carbolic acid and a ready solubility in water and the ordinary solvents, It is said to be an excellent antiseptic. Kronacher, Emmerich and others claim great virtue for it. Its odor is slight and it is said to be entirely free from irritating properties. It has been tried with apparent success in the treatment of wounds, sores and putrefactive disorders and many excellent reports of its virtues have been made. Unfortunately, however, it cannot be used for the disinfection of instruments for it attacks even silver and nickel plating; it also stains the hands and nails a light yellow.

Kronacher says that a one per cent solution is fully strong enough for surgical dressings,—indeed he has even used it in solutions as strong as 50 per cent.

DISINFECTOL.—This substance is usually termed a

coal tar product similar to creolin and largely used in Germany. The statement has also been made that it is a mixture of hydrocarbons, soaps, carbolic acid and soda. It occurs as an oily, dark-brown fluid, analogous to lysol and creolin, and slightly heavier than water. It is claimed that it possesses energetic disinfectant properties but if so this has not resulted in its general use. It has been employed locally in the form of an emulsion of a strength of two to five per cent.

Beselin concludes, after having made numerous experiments with it upon typhoid stools, that while superior to creolin in this respect, it has no advantage over carbolic acid.

ESSENTIAL OILS.—These have been found to possess varying values. Riedlin reports that the oils of lavender, eucalyptus, rosemary and cloves have the greatest antiseptic values of any of the essential oils. Cadeac and Meunier demonstrated that the typhoid bacilli were killed by oil of cloves in twenty-five minutes, by oil of Ceylon cinnamon in twelve minutes while oil of sandalwood required twelve hours.

ETHER.—$(C_2H_5)_2O$, or $C_2H_5OC_2H_5$. This substance is too familiar to need description. Yersin found that ten minute's exposure was sufficient to kill the tubercle bacilli but Koch found that anthrax spores would germinate even after eight day's exposure to the action of the same.

EUCALYPTOL.—$C_{10}H_{18}O$. The essential oil obtained by distillation from the eucalyptus. When pure it occurs as a colorless liquid with an odor somewhat similar

to that of camphor. It is iusoluble in water but soluble in the fatty oils, in alcohol, ether and chloroform. It is said to possess marked therapeutic properties but its chief use is as a local antiseptic in ulcers.

Behring has determined that it is four times less active than carbolic acid. Perret found that a five per cent solution had no effect upon tuberculous sputa.

Recently M. Anthoine has produced a new antiseptic, which he calls Eucalypteol, by the action of hydrochloric acid upon eucalyptus oil. This substance chemically is eucalyptene di-chlorid; it occurs in colorless, scaly crystals with an odor resembling camphor. It is almost tasteless. Lafage claims that it is far superior to eucalyptus oil as an antiseptic. It is practically insoluble in water and glycerin and readily soluble in ether, chloroform and alcohol, though decomposed by the latter.

Eugenol.—Also termed *Eugenic acid,* with a chemical formula $C_6H_3\ C_3H_5.OH.OCH_5$. This substance is a phenol derived from oil of cloves by oxidation; it may also be obtained from other various essential oils, such as those of sassafras, bay, pimento and cinnamon. It usually occurs as an aromatic liquid freely soluble in alcohol but only slightly so in water. The substance has been used internally as an antiseptic in doses of 45 minims *per diem,* in alcoholic solution. There is also a derivative, Ciunamyl eugenol, which occurs in colorless, odorless, tasteless crystals which are soluble in hot alcohol, ether, chloroform and acetone; it has been used in the treatment of tubercular diseases.

Euphorin.—This substauce is also termed *Carbonate*

of ethyl and phenyl, Phenyl-ethylic urethane and *Phenyl urethane.* It is represented by the chemical formula $C_6H_5NHCOOC_2H_5$. Euphorin must not be confounded with Europhen, which is an altogether different sub stance. Euphorin occurs in the form of a white powder with a slight aromatic odor and a taste like that of cloves. It is slightly soluble in water but freely so in alcohol. It is employed locally as a dusting powder; internally it is given in doses of 7–15 grains from two to three times a day. As a local application it is said to be more powerfully antiseptic but less dessicating than dermatol.

EUROPHEN.—*Iodo-di-iso-butyl-ortho-cresol* or *Di-iso-butyl-ortho-cresol-iodid* and is represented by the chemical formula $(C_4H_9.CH_3.C_6H_3O)_2HI$. It occurs as an amorphous powder, with a yellow color and an odor of saffron; it is soluble in alcohol, ether, chloroform and oils but insoluble in water. It is used chiefly locally as a dusting powder as a substitute for iodoform. It is also used hypodermically in the treatment of syphilitic disorders. Its best effects are obtained by a local use, and even then only by its application to secreting or otherwise moist surfaces. Kopp reports excellent results from a mixture of europhen and boracic acid. Christmann concludes from his experiments that the evolution of iodin is necessary before an exhibition of germicidal power—this is dependent upon the decomposition of the drug, as in the case of iodoform.

EXALGINE.—A substance, also termed *Methyl-acetanilid,* obtained by the action of acetyl chlorid upon mono-

methyl-anilid and possessing the chemical formula $C_6H_5N(CH_3)CH_3CO$. It occurs as a tasteless powder made up of crystalline, needle-like particles which are readily soluble in alcohol and sparingly soluble in water. It is said to possess antiseptic properties but these are not marked, at least not sufficiently marked to make the substance of any great value in this connection.

Ferric Chlorid.—$FeCl_3$, frequently given as Fe_2Cl_6. A 5 per cent solution of the substance required five days to destroy anthrax spores, failing to do so in two days. No marked germicidal power.

Ferrous Sulphate.—$FeSO_4$. Sternberg found that a 20 per cent solution failed to kill putrefactive organisms—that it was antiseptic, not germicidal.

Formalin.—H.COH. This substance is nothing more nor less than an aqueous solution of formic aldehyde of the strength of 40 per cent. It has its laurels yet to earn.

Formic Acid.—H.COOH. This irritating substance is formed either by the distillation of the bodies of ants, as was formerly done, or else by the oxidation of formic aldehyde, which is in turn produced by the oxidation of methyl alcohol. Kitasato determined experimentally that .35 per cent would destroy typhoid bacilli in five hours and that .22 per cent would produce a like result in the same time upon the spirilla of cholera.

Gallic Acid.—Abbot determined that a 2.37% solution destroyed the bacteria of broken-down beef tea but failed to kill anthrax spores in two hours. A solution of 1:142 killed various micrococci in two hours.

Glycerin.—$C_3H_5(OH)_3$. Glycerin was used as an antiseptic by Demarquay as early as 1855; he thought it the very best antiseptic substance, in fact almost a panacea; but it has been tried and found wanting. Roux and others have shown that the addition of five per cent of glycerin to culture media was *favorable* to their subsequent growth. Koch found that it had no effect upon the spores of either symptomatic anthrax nor indeed upon those of anthrax itself. Miquel has determined that its presence in the proportion of 1:4 will prevent putrefactive decomposition in bouillon.

Gold Chlorid.—$AuCl_3$. Also termed the tri chlorid, or *Auric Chlorid*. Miquel has determined that this substance is antiseptic in the proportion of 1:4000. A solution of 1:1000 will destroy the germs of cholera, anthrax or diphtheria.

Guaiacol.—This substance, also called *Methyl pyro catechin*, is obtained from beech-wood tar. Its formula is said to be $C_6H_4OHOCH_3$ and it is claimed to contain 60–90% of creosote. It occurs as a liquid having a pleasant odor and a specific gravity only slightly greater than that of water. It has also been produced synthetically as a solid product which is colorless and crystallizes readily in prismatic form; it has a sweetish and marked astringent taste and is said not to attack mucous membranes.

Guaiacol is soluble in water in the proportion 1:85 and in petroleum benzin in that of 1:8. It seems to have antipyretic, as well as antiseptic, properties—even when applied locally. Its chief use has been in tuber-

culous affections, and indeed wherever creosote may be exhibited with profit. It is said to prove an advantageous substitute for creosote in the early stages of tuberculosis. It is best administered after meals either in alcoholic solution, or mixed with cod-liver oil or else in capsules. The usual dose is from five to ten minims; continued use establishes a tolerance, as in the case of creosote, and the dose may be gradually increased if its full effect is to be exercised.

Various salts of the substance, such as the iodid, carbonate, salicylate and others, have been prepared and put upon the market as succedanea for guaiacol itself; the indications for their use are the same as those for guaiacol, the only virtue claimed for any of them over guaiacol is that they are supposed to possess the disadvantages, such as irritation, etc., in a more modified degree than the substance itself.

Helenin.—This substance is derived from elecampane root. It exists in the form of white acicular crystals with the chemical formula C_6H_8O These crystals are only slightly soluble in water but are readily so in hot alcohol, ether and the oils. It is claimed to be an effective antiseptic where it has been used in Europe. In Spain it is highly favored as a surgical dressing; indeed Ferran claims active germicidal properties for it, claiming that it is more destructive in its action upon the cholera bacillus than any other agent. It has been used with favorable results in pertussis, ozaena, diarrhea, leucorrhea and other disorders; but its excessive cost is an effective barrier to its general use. It has

been administered in doses of 1–6 to 1–3 of a grain in the course of twenty-four hours.

HYDROCHINONE.—Also termed *Hydro quinone, Para di oxy benzene* and *Quinol,* is obtained from Arbutin (which see) by the action of sulphuric acid, or else by the oxidation of anilin by chromic acid and has the chemical formula $C_6H_6O_2$.

It occurs in long, di-morphous colorless crystals which are freely soluble in hot water, alcohol or ether; soluble in cold water in the proportion 1:20. The substance has been recommended as an internal antiseptic and has apparently produced good results. It is usually administered in doses of from 1–2 to 5 grains.

HYDROGEN DI OXID (HYDROGEN PEROXID). — This substance is sometimes described as "an aqueous solution of hydroxyl," thus H_2O_2 or $(OH)_2$. The solution used in practical medicine is of about "ten volume" strength. It has been lauded as a general disinfectant and germicide. It has one great advantage in that it is non-toxic. It seems to possess a special predilection for pus, which it destroys; this property is made use of in some cases for the diagnostication of the presence of pus where it may be concealed in cavities—its presence causes a marked effervescence when the peroxid is introduced. Shimwell, however, says that it is not applicable to fresh wounds or fresh surfaces but to those that are septic in nature. It has lately been introduced into the U. S. Pharmacopeia of 1890.

Surgeon-General Sternberg says that unless chemists can furnish stronger and more stable solutions of the

substance than they seem at present able to do, we are not likely to derive any practical benefit from its use as a disinfectant. Indeed its instability is marked and forms the chief objection, since one cannot rely upon all preparations unless assured of their freshness. The substance owes all of its virtues to the oxygen which it disengages when brought into contact with oxidizable matter. The action of oxygen and ozone are discussed under their proper headings, which see for further information.

Hydrofluoric Acid.—HF. This substance, which normally exists in a gaseous condition, has been suggested and used in the treatment of tuberculosis. The experiments of Chautard and Grancher with the substance show that its direct and prolonged action diminishes the virulence of the germ but fails to kill it. Hydrofluosilicic acid or its sodium salt (Sodic silicofluorid, Na_2SiF_6) have also been suggested and indeed were highly praised by Neudorfer, but, as Shimwell properly says, have now been discarded having no advantage over boracic acid. Hydrochloric acid the congener of hydrofluoric acid is equal to sulphuric acid in germicidal power.

Hydronaphthol.—This substance is derived from Beta-naphthol by the substitution of hydroxyl (OH) for an atom of hydrogen, hence the chemical formula would be $C_{10}H_6(OH)_2$. It is soluble in water in the proportion of 1:900–1000. The drug has recently been suggested as a prophylactic in the treatment of cholera or other infectious affection of the alimentary tract. In

the proportion of 1:400 it is said to possess powerful germicidal and inhibitory power. Its internal use is resorted to in doses of eight to ten grains three or four times a day.

Indol.—Koch found that even an excess of this substance in water did not destroy anthrax spores, even in eighty days.

Iodin.—In 1853 Duroy pointed out the fact that iodin possessed preservative properties, having a direct action upon pus and organized ferments; also that it caused aqueous solutions to keep indefinitely and that its syrups do not ferment. These facts and many other similar ones he embodied in a memoir presented to the Academy of Medicine of Paris in the year 1853. Velpeau again called the attention of the medical profession to the virtues of iodin in the year 1859; he said that it had been in use at that time for thirty years or more. Modern researches have corroborated the germicidal properties of both iodin and bromin. In such strength iodin is considerably stronger than bromin but less strong than chlorin.

Iodin Tri Chlorid.—ICl_3. Behring claims that this substance, as an antisptic, has all of the potency of free chlorin or iodin without their disadvantages. It is a yellowish-red powder with a peculiar and penetrating odor; it is soluble in water. Langenbuch found that it would restrain the development of bacteria, when added to nutrient gelatin, even when present in as small an amount as 1:1200, while 1:1000 would kill even spores in a short time. A solution with a strength of one per

cent destroyed anthrax spores suspended in water almost instantly and a $^2/_{10}$ per cent solution effected the same result in a few minutes. Behring found that a one per cent solution would kill anthrax spores in blood-serum in forty minutes.

Iodoform.—CHI_3. Sometimes termed *Tri-iodo methane.* This substance is too familiar to need description. The chief objection to it is its intolerable and almost imperishable odor. The experiments of Tilanus, Neisser, Buechner and others show that it is no germicide itself but has some antiseptic power; that is, it possesses inhibitory power. Neudoerfer says that it possesses toxic properties for some individuals, that "they lose their appetites, become morose, absent-minded, and if the drug be continued there result physical changes and death."

Recent investigations have demonstrated that under certain conditions the substance does possess some germicidal power—that is, the decomposition of the substance, accompanied by the liberation of free iodin gives it the antiseptic and germicidal properties which are peculiar to iodin. Sir Joseph Lister has recently called attention to the antiseptic properties of iodoform, claiming however, that the function of the iodoform was not to kill the germs but to destroy the products of their vital activity. This is certainly an extraordinary claim and a most valuable property, if experience can but demonstrate its truth.

Iodoform is chiefly of value in various tubercular affections and remains the favorite remedy in such diseases.

Squibb says: "Its extremely disagreeable penetrating and persistent odor is still against it and deodorizers continue to be recommended from every quarter. It should be constantly borne in mind that the characteristic odor of iodoform is inherent to it and we might just as rationally expect to remove the sweetening property of sugar and still expect to retain the usefulness of that necessary article as to remove the odor of iodoform and retain its identity. We can adopt all manner of expedients to mask this objectionable quality, but we may rest assured that the iodoform is still there as long as we hold its combining elements together, and as soon as we split these up we no longer have this useful agent."

IODOL—This substance, obtained by the action of an alcoholic solution of iodin upon pyrrol, and called *Tetra iodo pyrrol*, has the chemical formula C_4I_4NH. It occurs in the form of a grayish-brown, odorless, tasteless powder; it is said to be yellowish and rather crystalline when pure. At elevated temperatures it decomposes, giving off vapors of iodin, It is soluble in alcohol and ether but almost entirely insoluble in water. It is claimed to be non-toxic and to possess the favorable qualities of iodoform in addition. Sternberg (1885) as a result of his investigations stated that it was entirely without germicidal power. Riedlin also found that it had no effect upon even the spirilla of cholera, which are among the least resistant of all germs.

IODOPHENIN.—Also termed *Iodo-phenacetin*. This substance is a combination of iodin and phenacetin and is

supposed to contain 50 per cent of the former substance. It is a brownish powder, but when pure exists as a crystalline body with a characteristic iodin like odor and a burning taste. Like iodin it discolors the skin yellow. It is soluble in alcohol, glacial acetic acid and boiling hydrochloric acid. Most of the reports, with the exception of those from the Paris Charity Pospital, are against the drug. Seibel says that it gives off iodin in excess too readily and that it possesses no advantage over free iodin itself. This observation has been confirmed and corroborated by other investigators also.

Iodozone.—This is the name given by Robin to a solution of iodin in ozone. The solution has all of the appearance of a complete one and gives no reactions by means of which a different condition can be detected. This was first suggested by the well known value of sea-air whose virtues were supposed by some to be due to ozone and traces of iodin. Iodozone is recommended as a spray in tuberculosis pulmonalis and open wounds —rather Iodozone *was* recommended in such cases, for it appears now to have utterly gone out of existence as a pharmaceutical or remedial preparation.

Izal.—This is a trade name for an emulsion containing thirty per cent of a new oil which it is claimed is produced by a patent process used for the manufacture of a special variety of coke. Squibb says that: "It appears to belong to a series analogous to the terpenes, with characteristics between those of the paraffins and the benzins. No phenol proper can be detected in the emulsion." It has not gone beyond the land of its birth

(England) as yet. It is claimed that it is a powerful antiseptic, that it does not injure the hands, that it has no objectionable smell, that it is non-toxic and in fact altogether valuable. This is based entirely upon the reports of a few enthusiasts, it is entirely too early to place any definite value, or lack of value, upon it as yet. Time will demonstrate its advantages, whatever they may be.

LACTIC ACID.—$HC_3H_5O_3$. The second member of a group of monobasic, di-atomic acids. It is a colorless syrupy liquid of strongly acid properties, mixing with water and alcohol in all proportions; it occurs in many plant juices, either free or combined. It is also produced by the fermentation or "souring" of milk.

Kitasato found that a .4 per cent solution would destroy the typhoid bacillus in five hours while a 3. per cent would do the same in the case cholera spirilla in the same length of time.

LANOLIN.—This substance is a fat extracted from sheep's wool and containing about thirty per cent of water—whence its name of *Adeps lanæ hydrosus.* It is a white odorless substance which does not affect litmus and is used as a base for many ointments or preparations used in the local treatment of diseases of the skin, etc. It is insoluble in water, partly soluble in alcohol and readily so in ether, acetone and benzene.

Gottstein found that various organisms ceased to grow after contact with pure lanolin from five to seven days; hence it appears to possess inhibitory powers. It is one of the best ointment bases known to pharmaceutical science.

Lead Chlorid.—$PbCl_2$. This substance is not in common or general use but Miquel has determined that it is antiseptic in the proportion of 1:500.

Lead Nitrate.—$Pb(NO_3)_2$. This substance is frequently credited with germicidal properties which it does not really possess. Miquel has determined that it is antiseptic in the proportion of 1:277.

Losophan.—*Tri-iodo-meta-cresol.* This substance is a new antiseptic produced by the action of iodin upon *m*-oxytoluic acid. It occurs in the form of colorless, needle-like crystals containing about eighty per cent of iodin. It decomposes readily in dilute solutions of alcohol, but not in solutions containing seventy-five per cent of alcohol. Its use is, as yet, restricted almost entirely to dermatology.

Lysol.—This substance is the saponified product of coal-tar; it is obtained from tar-oils by boiling with alkalies and fats and contains about fifty per cent of cresols. It occurs as a clear, brown, oily liquid slightly lighter than water and with an aromatic odor like that of creosote. It is soluble in alcohol, chloroform, water, glycerin, carbon di-sulphid and benzin. Experience has not justified the extraordinary claims which have been made for it. Its soapy nature renders instruments or objects immersed in solutions of the substance disagreeably and dangerously slippery.

Cadeac and Guinard, after elaborate experimentation with the substance, have concluded that while it is an undoubted microbicide it has no advantage over the antiseptics of established reputation; that it is only efficacious in solutions sufficiently strong to prove irritat-

ing or caustic and that its sphere of usefulness will not extend beyond the disinfection of stools, privies, ships, stables, etc., aiding thus in the prophylaxis, prevention and arrest of epidemics. It is used by some locally in solutions of strengths of from three to five per cent.

Malic Acid.—Has about the same germicidal value as citric acid.

Mercury.—The various soluble salts of this metal seem all to have more or less antiseptic activity although the fallacious belief in their unsurpassed *germicidal* powers has been entirely exploded by the results attained by recent investigators. The succinate, the phenylate, the salicylate, the thymol-acetate, the thymolate, the iodid, the cyanid and a host of others have their respective adherents. None of them however have attained the eminence of the so-called "bi chloride." Mercuric iodid however is but slightly inferior to this chlorid; it is moreover, more stable, less toxic and altogether more agreeable. According to Lister, until his recent declaration in favor of carbolic acid above all other germicides, the double cyanid of mercury and zinc more nearly accorded to the requisites of an ideal antiseptic. This substance is non-volatile, non-irritant, insoluble to the extent that wound secretion does not wash it out of the dressing; its great disadvantage, however, is its feeble germicidal power which is almost balanced though by its inhibitory power. (See Corrosive Sublimate).

Methylene Blue.—This substance is one of the anilin dyes, being called *Tetra-methyl-thionin.* The

drug is usually found as a bluish powder composed of scaly crystals of a bronze-like tinge; it is somewhat soluble in water and more so in alcohol. It has been recommended especially as an antiperiodic, particularly where quinine has failed. It has also been used locally in diphtheria. (See Anilin Dyes).

MICROCIDIN.—This name is applied to a mixture of beta-naphthol and sodic hydroxid—it is presumably termed sodic naphtholate. It is a white powder soluble in water in the proportion of 1:3. It is employed as an antiseptic both internally and externally. When used locally it is employed in the strength of from three to five parts to the thousand. It is but little heard of now, although Cozzolini of Naples thinks that it has given him excellent results in suppurations of the ear and in inflammatory conditions of the nose and throat.

MONO CHLOR-PHENOL (see CHLOR-PHENOL).

MORPHIA HYDROCHLORATE —This substance has feeble inhibitory powers. Miquel has decided that it is antiseptic in the proportion of 1:13.

NAPHTHALENE.—Also termed *Naphthalin*, having a chemical formula of $C_{10}H_8$. It is a hydrocarbon obtained from coal-tar; it is also formed in the manufacture of ordinary illuminating gas. As usually found it occurs as a grayish white substance either in powder or brilliant, scaly crystals which have an odor of coal-tar and an aromatic bitter taste. It is soluble in alcohol ether, the fixed and volatile oils and in acetic acid, but insoluble in water. Is is also sold in molded blocks under the name of *Alabastrime* and *Camphylene* and

used for preserving furs and flannels from moths and also in urinals for purposes of disinfection. It is claimed that the inhalation of the vapor of the substance has given good results in the treatment of pertussis, etc.

Naphthol.—Also termed *Naphthyl alcohol* and *Iso-* or *Beta-naphthol.* It may be obtained by the action of sulphuric acid for some time upon naphthalene. The chemical formula is $C_{10}H_7OH$. It occurs in brilliant, colorless, shining, crystalline laminæ having an odor resembling that of phenol, with a slight burning taste. It is readily soluble in alcohol, ether, chloroform, benzene and the fatty oils; it is fairly soluble in hot water but almost insoluble in cold water. It is used as an antiseptic in cutaneous diseases and affections of the respiratory tract, also as an intestinal antiseptic. Foote says that the substance exercises some germicidal power even in the proportion of 1:2300 but concludes that a saturated aqueous solution (1:1150) does not equal the action of one per cent solution of carbolic acid or of creolin.

It has been used internally in the dose of two to fifteen grains and ezternally in solutions or ointments of the strength of from 2 to 10 per cent.

There are a great number of derivatives of naphthol such as iodo-beta naphthol, benzo-naphthol, microcidin, naphthol camphor, etc. It is undoubtedly an efficient antiseptic, as indeed are many of its derivatives, but, as Squibb says, "Naphthol and all its derivatives cannot be said to have superseded carbolic acid, although they no

doubt will find a permanent place on the list of valuable agents."

Nitric Acid.—HNO_3. This substance is too well known to need description. Nitric, hydrochloric and sulphuric acids are approximately of the same germicidal strengths. (See sulphuric acid).

Nitrous Acid.—HNO_2. Nitrous acid represents the first degree of reduction or de-oxidation of nitric acid. Sternberg (1880) determined that the activity of dry vaccine virus was destroyed when exposed upon ivory points for six hours to the action of an atmosphere containing one per cent of nitrous acid.

Oil of Mustard.—The presence of this substance in the proportion of 1:33000 is sufficient to prevent the *development* of anthrax spores, though so weak a preparation does not kill them.

Oil of Turpentine.—Koch found that though oil of turpentine failed to destroy the spores of anthrax in one day they were destroyed by such exposure for five days; he found also that their development was effectually prevented by the presence of the substance in the proportion of 1:75000. Christmas, in his experiments upon the pus cocci, says that an excess of oil of turpentine added to liquefied gelatin cultures of the *Staphylococcus pyogenes aureus* was unable to destroy the micrococci even in eight hours.

Oleic Acid.—$HC_{18}H_{33}O_2$. Oleic acid is a constituent of most facts, especially oily fats—olive oil for instance being almost entirely an oleate of glyceryl. The experiments of Koch seem to indicate that the substance

has little if any antiseptic power. A five per cent solution in ether failed to destroy anthrax spores in five days.

Olive Oil.—This substance, as has been stated, is almost entirely, when pure, glyceryl oleate. Koch has determined that anthrax spores germinate even after ninety days immersion in this substance; indicating an apparent absence of any germicidal action whatsoever.

Osmic Acid.—H_2OsO_4. Koch has determined that this substance will kill anthrax spores in twenty-four hours if present in the strength of one per cent. Miquel has determined that the substance is antiseptic in the proportion of 1:6666.

Oxalic Acid. — $H_2C_2O_4$. Kitasato has determined that this substance, in the strength of .36 per cent, will destroy typhoid bacilli in five hours and that a solution of the strength of .28 per cent will kill cholera spirilla in the same time.

Oxygen.—This element exists in two conditions—one the free and normal element whose molecule is expressed by the symbol O_2 and the other, an allotropic modification,termed ozone whose molecule is represented by the symbol O_3. Free oxygen is necessary for the development of a large number of species of bacteria—indeed it is essential to all aerobic species; on the other hand it completely prevents the growth and development of the anaerobic species.

Oxygen has no great power of destruction of bacteria unless *nascent*—that is, freshly generated. The common belief is that all oxygen under all conditions is possessed

of marvelous powers over germ life—such is not altogether the case. Indeed, as we have said, the presence of oxygen so far from being restrictive is absolutely necessary for the development and growth of all aerobic species. Nascent oxygen, on the other hand, is a potent agent—indeed it is to the virtues of the element generated in this peculiar condition that potassic permanganate, and other oxy-antiseptic substances owe their entire antiseptic powers. Duclaux says that oxygen has the power of destroying bacteria but that it is exceedingly difficult to make an application of the substance to man except in the form of "oxygenated water" (it is thus that he designates hydrogen peroxid) which, as he says, has not always given the most happy results to those using it. Indeed although hydrogen peroxid is a valuable antiseptic and deodorant its germicidal value is highly overestimated.

OZONE.—It was formerly supposed that this allotropic modification of oxygen would prove to be a valuable antiseptic agent but unfortunately for its reputation in this respect recent experiments show that it does not possess the anticipated activity—indeed that it possesses little value from a practical standpoint.

Lukaschewitsch found that one gramme in the space of a cubic metre utterly failed to kill anthrax spores even in twenty-four hours. So much for its vaunted activity. Then also, Sonntag, Friedlaender, Nissen and others secured negative results in their experiments upon the germicidal activity of this substance. So far from being the valuable agent previously supposed, a

careful consideration of all of the experimental data leads one to the conclusion that, as a germicide, ozone is utterly devoid of practical value in therapeutics and disinfection. It is possible that the splitting up of a molecule of ozone may yield us either nascent oxygen or else a mixture of molecular and nascent oxygen, thus:

$$O_3 = O_2 + O$$

in this case whatever germicidal action may ensue is due not to the ozone, for it has been destroyed the moment that the molecule O_3 has been decomposed, but to the nascent oxygen set free. Ozone then would have less virtue than any of the various processes by means of which nascent oxygen itself is generated.

Paracresolal.—This substance, also called *Cresalol*, is paracresolic salicylate and is represented by the chemical formula $C_6H_4.OH.COO.C_6H_4CH_3$. It occurs as a whitish crystalline powder with an odor like that of salol, it is insoluble in water but slightly soluble in alcohol. This substance, which is strongly analogous to salol (phenylic salicylate) in its therapeutic functions, is used more largelv, as is salol, as an intestinal antiseptic in doses of from three to thirty grains *per diem.*

Phenol.—(See carbolic acid).

Phenocoll.—This substance is also termed *Amido-para-acet-phenetidin.* It has been more largely used, not only itself but also in the form of the hydrochlorate or hydrochlorid and salicylate (Salocoll), as an antipyretic. The acetate and carbonate have also been used for this same purpose. Certain investigators have called the attention of the medical profession to the an-

tiseptic value of the substance. Dr. Beck of New York conducted experiments with a view to determining the exact value of such properties of the substance. He found that phenocoll excelled phenacetin, acetanilid, and iodol in such activity and indeed even excelled iodoform to which he considered it superior otherwise on account of the ready solubility of phenocoll, its freedom from odor and irritating properties and its freedom from toxic properties. The substance occurs as a white crystalline powder readily soluble in water or alcohol but very sparingly soluble in benzol, chloroform or ether.

PHENOLID.—A 50 per cent mixture of acetanilid and sodic-bi-carbonate; it seems to have passed entirely from use.

PHENO-SALYL.—This substance is not a definite compound but a mixture of four or five substances. The formula is as follows:

Carbolic acid,	about	9 parts.
Lactic acid,	"	2 parts.
Salicylic acid,	"	1 part.
Menthol,	"	$^1/_{10}$ part.

The menthol is added to the combined acids which are heated up to the point of liquefaction. The mixture is said to be soluble in water to the extent of making a 4 per cent solution. The formula has been somewhat extended by the addition of eucalyptol to the other ingredients; this is mixed in small quantity along with the menthol and then the whole resulting mixture is mixed with four times its volume of glycerin. The formula was introduced by Dr. Christmas after some

experimentation at Pasteur's Institute in Paris. Dulerly reports its successful use in various uterine affections, in gonorrhea and as a wash for rectal sores and ulcerations. Yersin claims that it is especially effective against the bacillus of anthrax—indeed he gives it high antiseptic power which, if present at all, must be due to the large amount of carbolic acid (about 75%) present in the mixture; it must however be inferior to carbolic acid when combined, as has been suggested, with other acids of higher activity, such as hydrochloric or boracic acids—indeed in the latter case an excellent substance results. The latter fact has at last been properly appreciated and a combination of carbolic and boracic acids has been put upon the market under the name of *Sennine*—named after Senn, who has done so much for the advancement of antiseptic principles in American surgery. For a full description of this substance see the article Sennine under its proper and appropriate heading. Because of the introduction of such superior and more valuable compounds Pheno-salyl and analogous substances are passing out of general use—indeed Pheno-salyl has already done so according to Squibb.

Phosphoric Acid.—H_3PO_4. This substance, the ordinary tri-basic or ortho-phosphoric acid, hardly needs description. Kitasato hss conducted experiments with a view to a determination of the germicidal activity of the substance, using an acid which contained 152 milligrams of acid per cubic centimetre. A solution containing three-tenths of one per cent (.3%)of this preparation destroyed typhoid bacilli in from four to five hours

while a solution of .183 per cent strength (that is, slightly more than one-half as strong) killed the spirilla of cholera in the same time.

Picrol.—This substance is *Di–iodo–resorcin–mono–sulphonic acid.* It is a new antiseptic, said to contain aboubt 52 per cent of iodin, and is described by Darzens and Dubois as possessing great potency. It is prepared by adding, while constantly stirring, an alcoholic solution of iodic acid and iodin to resorcin·mono·sulphonic acid, produced by the action of concentrated sulphuric acid upon resorcin. The potassium salt of this substance is usually described as existing in the form of colorless, odorless crystals with an exceedingly bitter taste. These crystals are readily soluble in water and the ordinary solvents. It is usually considered non-toxic but its reckless use is not without danger. It is too soon to express an opinion on the status or value of the substance as no clinical reports of its use have been collaborated as yet.

Piperonal.—$C_8H_6O_3$. This substance is also termed *Heliotropin* and is obtained from piperic acid by oxidation. It usually occurs in the form of white and scaly crystals which are soluble in alcohol and ether but are insoluble in water. At present the substance is more generally employed in the arts, in the manufacture of perfumes, though its use as an antipyretic and antiseptic has been suggested; such use has been largely restricted by the exceedingly high price of the substance. When administered it is usually given in single doses of about fifteen grains.

POTASSIC ACETATE.—$KC_2H_3O_2$. This substance is the potassium salt of acetic acid, analogous to plumbic acetate ("Sugar of Lead") which is the lead salt of the self-same acid. It is hardly necessary to describe its chemical and physical properties. Suffice it to say that Koch found that a saturated solution of the salt in water failed to kill anthrax spores in ten days.

POTASSIC ARSENITE.—This substance, or rather the potassic hydrogen arsenite which has the chemical formula $KHAsO_3$, is used in medicine under the name of "Fowler's Solution." It is an acid potassium salt of arsenous acid. The substance has been found to possess absolutely no germicidal action. It may be slightly antiseptic however for Miquel has determined that it is so in the proportion of 1:8.

POTASSIC DI-CHROMATE.—$K_2Cr_2O_7$. This substance, which exists in beautiful yellowish-red crystals, was supposed to possess active germicidal properties but the experiments of Koch demonstrate that a five per cent solution failed to destroy anthrax spores even after two days exposure. Miquel has determined, however, that it is antiseptic in the proportion of 1:909.

POTASSIC BROMID.—KBr. This substance is more familiarly known and used as a nerve sedative or a hypnotic but Kitasato has proven that it also possesses antiseptic and indeed even germicidal properties. He found that when typhoid bacilli and cholera spirilla were immersed in a solution containing from 9 to 10.6 per cent of potassic bromid they failed to grow. Indeed they were killed when exposed for four or five hours to

the action of solutions with strengths of 10–12 per cent.

Potassic Carbonate. — K_2CO_3. Kitasato has also proven the antiseptic and germicidal action of this substance. He found that the development of typhoid and cholera germs was prevented by solutions containing as small an amount as .74–81 per cent and indeed even killed by five hours exposure to the action of a one per cent solution.

Potassic Chlorate. — $KClO_3$. This substance is probably more familiarly known to many of us as chlorate of potash, in common use for the treatment of the various inflammatory conditions of the naso-pharynx. Its efficacy in such affections together with their frequent micro-organic nature led many to suspect that the drug had a specific action which was due, it was thought, to a specific action of the substance upon the germ directly. Contrary to the general belief, the substance is devoid of any germicidal power. A careful consideration of the experimental data now at our disposal forces this conclusion upon us. Sternberg found that a four per cent solution failed to destroy or kill the *Micrococcus Pasteuri* even after an exposure of two hours to its action. Koch also found that a five per cent solution failed to kill anthrax spores in five days.

Potassic Chromate.—K_2CrO_4. This substance is apparently no stronger than the chlorate of potassium, for Koch found that a five per cent solution failed to kill anthrax spores in five days, as was the case with the chlorate.

Potassic Cyanid.—K (CN). This substance seems

to possess little or no germicidal power—indeed Miquel gives it the same power in this respect as potassic dichromate, that is it is antiseptic in the proportion of 1:909.

Potassic Hydroxid.—KOH. This substance is more familiar to many, especially those who studied Chemistry when the old system of nomenclature was in vogue, as "caustic potash" or as potassium hydrate. Sternberg demonstrated that while an eight per cent solution was unable to destroy the pus cocci in two hours a ten per cent solution of the same substance was able to effect this result in the same time. Kitasato found that an .18 per cent solution would kill the typhoid bacillus in from four to five hours while a .237 per cent solution was required to effect the same result in the same time with cholera spirilla. This fact presents a curious and interesting condition. Usually the spirilla of cholera are less resistant than the bacilli of typhoid fever but here we have the reverse true; as a rule the cholera germ is especially susceptible to the action of acid antiseptic solutions. In this case we have an alkaline substance and the spirilla are less susceptible to its influence than the typhoid bacilli.

Potassic Iodid.—KI. This substance, more commonly called iodide of potash, is used frequently in the treatment of certain stages of syphilis and also of rheumatism, etc. It has been determined that it possesses slight germicidal properties though these are not present to a marked extent. Koch demonstrated that a five per cent solution failed to destry anthrax spores in eighty

days. The typhoid bacilli and the cholera spirilla fail to grow in an eight per cent solution, but are destroyed by five hours exposure to a 9.23 per cent solution. Miquel has determined that it is antiseptic in the proportion of 1:7, a very low power.

Potassic Permanganate.—$KMnO_4$, or in the older system $K_2Mn_2O_8$. The experiments of Jaeger show that a one per cent solution is not reliable for the destruction of pathogenic bacteria but that a five per cent solution is very effectual, although it does not kill the bacillus of tuberculosis. Miquel has determined that it is antiseptic in the proportion of 1:285.

The experiments of Kelly, Welch, Robb, Ghriskey and others, at the Johns Hopkins University, upon the various cocci and the germs usually found upon the hands and beneath the nails of physicians and surgeons, indicate that exposure of the hands to the action of a saturated aqueous solution of the substance with a further bath in a saturated aqueous solution of oxalic acid to remove the stain of the permanganate and to reinforce its germicidal action was by far the most efficient means of sterilization of the hands—especially if preceded by a thorough scrubbing of the hands and nails with brush, warm water and common soap. They found by rigid experiment that this was far superior to the action of corrosive sublimate as used in Fuerbringer's method, so commonly resorted to in obstetrical and surgical practice for the sterilization of the hands of the operator. Many operators of advanced opinions are

now adopting the permanganate method so highly favored by Kelly.

PYOKTANIN.—This is a name patented by Merck for the two anilin dyes more commonly known as *methyl-violet*, or yellow pyoktanin, and *methyl-blue* or blue pyoktanin. The substance occurs as an odorless powder which is soluble in alcohol and soluble in seventy-five parts of hot and fifty parts of cold water. This substance has had remarkable exaltations and damnations in its short career as an antiseptic. (See *Anilin dyes*). Certain oculists and laryngologists have claimed to obtain benefit from its use. Roswell Park and others say that its use is disappointing if not entirely worthless, which latter term he thinks more nearly describes the value of the medicament. Dr. Doering claims very favorable results from its local use in diphtheria. Goldschmidt has pronounced it useless in *Lepra tuberosa*. N. S. Roberts says that "it is of much less value than the standard remedies now in use, but is worth thinking of when these fail."

It has the great disadvantage of highly coloring the skin or clothing, being an anilin dye and having all of the intense coloring power peculiar to that class of substances. It not only stains the skin and clothing but the dressings and the hands of the operator himself. This produces exceedingly disagreeable results. Moreover, prolonged contact with certain of the anilin dyes has been productive of various eczematous conditions of the skin.

PYROZONE.—This is a name given by its manufacturer

to a preparation of a concentrated solution of hydrogen peroxide in ether. It is claimed that it contains about fifty per cent of the peroxid; it seems to be an efficient agent as far as hydrogen peroxid can be, having all of the properties of that substance which is its aotive principle.

Quickine.—A trivial, silly and senseless name for what the manufacturer terms "the new antiseptic, anti-pyretic and antizymotic." When we consider the formula it puzzles one to discern how even the wildest of dreams could ascribe antipyretic properties to the substance. According to the *Pharmaceutische Zeitung*, Quickine consists of one part of corrosive sublimate, fifty of carbolic acid and fifty-two of dilute alcohol. It consists, according to Squibb, of one part of pure carbolic acid, two-hundredths of a part of corrosive chlorid of mercury and *one-thousandth* of a part of a mixture of alcohol and water. All of this, as Squibb satirically quotes, is manufactured by a process of "dynamization and potentialization that guarantees to the medical profession the absolute accuracy and uniformity" of the product—or rather mixture. That it has met with little or no success is shown by the fact that in spite of the adoption of catch-penny methods it has been relegated to innocuous desuetude. Whatever of virtue the substance possessed was due to the presence of carbolic acid and corrosive sublimate; these virtues were no greater than those attained by the use of the substances themselves. Hence, having no claim to attention, the mixture has died a death of inanition.

Quinine.—This alkaloid and its salts are too familiar to the physician to need description. These substances, although possessing no marked germicidal power, are yet somewhat antiseptic. The experiments of Arloing, Cornevin and Thomas have proven that the sulphate, in ten per cent solution, does not destroy the bacilli of symptomactic anthrax. Sternberg found that the sulphate, in the proportion 1:800, while it did not destroy various micrococci and bacilli upon which he experimented, yet had the power of preventing their development—that is, in such proportion it was antiseptic but not germicidal. Miquel has determined that the hydrobromate is antiseptic in the proportion 1:182 and Ceri has determined that the hydrochlorate is antiseptic in the proportion of 1:900—that is, its antiseptic power is greater than that of the hydrobromate.

Resopyrin.—This substance M. Portes describes as a compound resulting from the mixture of resorcin and antipyrin in solution in the proportion of their chemical equivalents. It occurs in oblique, colorless crystals which are usually of a rhombic and prismatic structure; it is soluble in alcohol but insoluble in water.

The substance has been known for several years but has now practically passed out of use.

Resorcin. — $C_6H_4(OH)_2$. This substance is also termed *Meta-di-hydroxy-benzene*, *Meta-di-oxy-benzene* and *Resorcinol*. As the chemical formula indicates, it is a di-atomic phenol. It may be produced synthetically from benzene but is also made by fusing different resins, such as those of asafetida, galbanum, etc., with the

fixed or caustic alkalies. Resorcin is a yellowish or white, flocculent or crystalline powder with a somewhat sweetish and pungent taste and a slightly aromatic odor somewhat resembling that of normal fresh urine. It is soluble in about its own weight of water; it is also soluble in alcohol and ether but very sparingly soluble in chloroform, carbon di-sulphid or benzene. Resorcin is used to some extent in the arts in the manufacture of certain dyes.

Resorcin is said to possess antiseptic properties and on that account is of use in the treatment of various diseases of the stomach and intestinal tract. Its use has been recommended in dysentery, cholera infantum, gastric ulcer, gastritis, diphtheria and affections of the larynx, pertussis and also, by Unna, in acne rosacea. For local use, solutions of 1–3 per cent may be used, or ointments of 5–10 per cent, or even in some cases as high as 25 per cent may be exhibited. When used internally resorcin is usually administered in doses of one or two grains.

RETINOL.—$C_{35}H_{16}$. This substance, also termed *Resinol* and *Rosinol*, is obtained by the distillation of Burgundy pitch, or pine-resin. It occurs as a thick, oily and yellowish liquid, slightly lighter than water. It is said to be a good antiseptic; it is used chiefly as a solvent for various drugs, such as salol, aristol, iodol, creosote, carbolic acid, camphor, cocaine and other similar bodies; indeed the effects of such medicaments are often enhanced by the antiseptic properties of the retinol used as the vehicle.

Desnos, a French observer, has reported very gratifying results from the use of solutions of 5–10 per cent of salol in retinol in certain cases of sub-acute cystitis. He has claimed that it frequently affords prompt relief even after other agents have failed. The peculiarity of the solution is, it is said, that it will remain in the bladder even after from six to eight distinct acts of micturition—of course in such case there is a diminution in quantity after each urination but all is not voided at one act. When used locally retinol may be applied in substance or in ointment; internally it is administered in doses of about one grain.

SACCHARIN.—$C_6H_4.CO.SO_2NH$. This substance is also termed *Gluside*, *Glucusimide*, *Benzoic sulphinide*, *Benzoyl-sulphonic-imide* and *Anhydro-ortho-sulphamine-benzoic acid.* Saccharin is a derivative of benzoic acid theoretically; practically however it is produced from toluol by a series of complicated synthetical processes.

Saccharin occurs as a white, amorphous or somewhat crystalline powder with an intensely saccharine or sweet taste followed by a slightly bitter after-taste and has a slight odor of bitter almonds—this odor becomes more prononnced upon heating the substance. It is soluble in alcohol and ether, also in glycerin, dilute ammonic hydroxid and in an aqueous solution of sodic bi-carbonate. It is only sparingly soluble in water—one part dissolving in about 230 of water; this solution is intensely sweet and is somewhat acid in reaction. The intense sweetening power of saccharin is its chief characteristic—it is even perceptible when saccharin is dissolved in 70,-

000 parts of water, being nearly three hundred (280) times sweeter than ordinary cane sugar. It is employed as a sweetening agent in diabetes where the use of sugar is interdicted. It is also a good antiseptic and is said to have given marked benefit in the treatment of cystitis. It has also been used as a vehicle to mask the taste of intensely bitter remedial agents.

Saccharin may be used either locally or internally; the dose is said to be indefinite.

SALACETOL.—Also termed *Salicyl–acetol.* This is a new synthetic product obtained by Fritsch by the decomposition of sodic salicylate by means of mono-chloracetone, while heat is applied. It has been proposed, like salophen, as a substitute for salol. It occurs in fine acicular crystals or scales with a slightly bitter taste. Salacetol is but sparingly soluble in cold water, but freely so in hot alcohol and the other various ordinary solvents.

It has been used by Bourget of Switzerland in doses of 30-45 grains in incipient diarrhea and choleraic affections. It has also said to have given good results in gout, sub-acute rheumatism and various genito-urinary affections.

It is too soon however to express a positive opinion as to its value or its probable status in therapeutics.

SALICYLAMID.—$C_6H_4.OH.CO.NH_2$. This substance is an amido compound or derivative of salicylic acid; it was first prepared by Limpricht by treating oil of wintergreen with saturated ammonic hydroxid, it has since been prepared by the action of the latter substance upon

methyl salicylate (the artificial oil of wintergreen), or by the action of heat upon ammonic salicylate. Salicylamid usually occurs in the form of colorless, thin, transparent laminar crystals, which are tasteless, leaving a sensation of grittiness in the mouth. It is soluble in alcohol, ether and chloroform; in water it is soluble in the proportion of 1:250.

It has been recommended as a substitute for salicylic acid, and it is said to have several advantages over the latter drug, being tasteless, more soluhle, more prompt and powerful in action and possessing greater analgesic power. It has also germicidal powers similar to those of salicylic acid. It is claimed that it has been used with good results in tonsillitis, chronic rheumatism, ovarian pains, neuralgia, etc. When used internally, ahout fifteen grains are administered *per diem*, in doses of from three to five grains each.

Salicylic Acid.—$C_6H_4.OH.COOH$. This substance has heen known to chemists for some time, but its introduction into medicine has been comparatively recent. Kolbe found that it could he prepared by treating a solution of carbolic acid in sodic hydroxid with carhon di-oxid at a moderate degree of temperature. It may also be obtained by fusing potassic hydroxid with salicin, the latter substance being a glucoside found in willow bark. Salicylic acid occurs in several species of violet; it also exists as the methyl salt in oil of wintergreen. It is usually sold as a dull white powder, or in long acicular crystals; it has usually a peculiar aromatic and pungent odor, and a peculiar sweetish yet

acrid or acidulous taste, which, as Wood says, is accompanied by a transient sense of numbness. Salicylic acid is readily soluble in hot water, alcohol, ether etc., and but sparingly soluble in cold water and glycerine. It is irritant to mucous or fresh wound surfaces.

The drug is usually described as non-toxic, but Quincke, Ogston, Empis, Gubler and Dixneuf, as well as others, have reported cases of death from the substance —indeed, in one case reported, death ensued as a result of the administration of forty-eight grains in four hours. The acid has the peculiar property of macerating flesh, and in this way sometimes attacks the hands when used as an antiseptic—it is owing to this peculiar property that salicylic acid is an almost constant ingredient of the various forms of "corn salves." It is also readily absorbed and is eliminated largely by the kidneys and hence is found in the urine.

Kolbe found that the presence of .04% had great influence in preventing the souring of milk; on account of this property it is widely used in beer, and in perishable food products, to prevent fermentation and decomposition, although such use has been forbidden in some countries. Sternberg found that a two per cent. solution destroyed pus cocci in two hours. Abbott found that micrococci were destroyed by a solution of the strength 1:400. Kitasato found that 1 6% destroyed typhoid bacilli in five hours, and that 1.3% produced the same effect in the same time upon cholera spirilla. A four per cent. solution however failed to affect the organisms of broken-down beef solution. Koch also found that a

five per cent. alcoholic solution failed to destroy the spores of anthrax. Miquel has determined that the substance is antiseptic in the proportion 1:1000.

The substance was introduced into surgery by Thiersch, of Leipzig, as a substitute for carbolic acid; it was then thought to possess as much germicidal efficiency as carbolic acid, but experience has failed to demonstate this, moreover it is irritant. As Wood says in his classic work upon Materia Medica and Therapeutics, "There can be no doubt that salicylic acid is capable of accomplishing much in antiseptic surgery, *but it does not seem to be replacing carbolic acid, as it at one time bid fair to do.* Its freedom from odor and comparative freedom from poisonous and irritant (?) properties are certainly strong recommendations in its favor; nevertheless, carbolic acid is more generally employed, and Mr. Callender, after twelve months' trial in the wards of St. Bartholomew's Hospital, has formerly condemned salicylic acid as much inferior to carbolic acid."

It can be used dry with good effect, but it does not adhere firmly to the parts, and therefore in the presence of free secretion it is washed away, leaving the wound surface exposed to infection. In acid diarrheas and fermentative conditions of the intestinal tract it owes its chief value to its restraining and inhibitory influence upon the development and vital activity of the various micro-organisms to which the acid intestinal fermentation is due, rather than to direct germicidal action.

The sodium salt of the acid, sodic salicylate, is said

to be a feeble antiseptic and hardly worthy of the name. Indeed all of the salicylates have much less power than the free acid.

Salocoll.—This is but the trade name for the salicylate of phenocoll; it is claimed to be more advantageous than the hydrochlorate, being less soluble and therefore freer from the disagreeable concomitant and after-effects. It is said to have been used with satisfaction in influenza.

Salol.—Also called *Phenyl salicylate*; it is represented by the formula C_6H_4 $OH.COOC_6H_5$. It usually occurs as a white crystalline and tasteless powder with a slight aromatic odor; it is soluble in alcohol, ether, turpentine, sandalwood oil, copaiba balsam and the fixed oils, but is insoluble in water. The substance has been suggested as a succedaneum for salicylic acid; it has also antiseptic properties. The drug is said to be of value in diseases of the urethra and bladder and in inflammatory affections of the pharynx and respiratory tract. It has also been used locally in coryza, ozena, skin diseases and as a dusting powder. But by far its most important application is in infectious disorders of the intestinal tract. This is dependent upon the fact that under the influence of the alkaline fluids of the intestines the substance is split up into its components, carbolic and salicylic acids. Loewenthal and others have praised its value in Asiatic cholera, but Reiche says that the experiecence of the Hamburg epidemic of 1892 was sufficient to demonstrate that the drug was useless in this affection whether given internally or by

injection in ethereal solution. Reynier believes that the internal use of the medicament will sterilize the urine unless pus be present in large amounts; for this purpose its administration must be continued for some time. It is probably inferior to boric acid in this respect however.

It is usually administered in doses of 5 to 30 grains. It is folly to expect this amount to sterilize completely the many square feet of mucous membrane of the intestinal tract, especially when loaded down with infectious material. To produce the best results from its use complete catharsis, followed by irrigation, must precede its administration.

SALOPHEN. — Also termed *Acetyl-para-amido-salol.* The chemical formula is $C_6H_4.OH.COOC_6H_4.HCOCH_3$. It is a new synthetic product, the first stage of the manufacture of which is the mixture of equal parts of para-nitro-phenol and salicylic acid. Then follow a series of more or less complicated changes, which result in the ultimate formation of the completed product, which occurs in small, thin, lamellar crystals which are odorless, tasteless and have a neutral reaction upon litmus. Salophen is freely soluble in alkalies, ether and alcohol, but practically insoluble in water

This substance is proposed as a substitute for salol. The gastric juice has no effect upon it, but when it comes in contact with the alkaline pancreatic secretion it is broken up into salicylic acid and acetyl para amido-phenol, which latter is eliminated by the urine and the feces. W. H. Flint, of New York thinks the sub-

stance of special value in acute rheumatic arthritis; indeed Hitschmann claims that it is almost a specific in such condition. These results and conclusions were also reached by Hare, E. Koch, Oswald and Hardenbergh. E. Koch in experiments upon the value of salophen says that its antiseptic action is trifling, but that its chief field is in nervous affections of various forms, such as neuralgia, hemicrania, cephalagia, sciatica, neuritis, pleurodynia, etc. The remedy when used internally is exhibited in doses of from one to one and a half drachms daily.

Sanitas.—This suhstance, which is used as an external disinfecting fluid, contains of an aqueous solution of turpentine, which has hecome oxidized hy the oxygen of atmospheric air; it contains camphor, thymol, hydrogen peroxid and a small amount of camphoric acid, the result of such oxidation. It is prepared by Kingzett hy passing air and steam through oil of turpentine. It is said to be a good antiseptic and to he free from poisonous properties; it is used chiefly as a domestic disinfectant. To judge by the formula one would hardly give the preparation high germicidal power however. Its use seems on the decline at the present writing.

Saprol.—Also termed "Disinfection Oil." This substance is a dark and hrownish oily mixture, consisting chiefly of crude cresols in an excess of those liquid hydrocarbons of the marsh gas series which are ohtained in the refining of petroleum.

Laser found that the application of one per cent. of

saprol was sufficient to sterilize urine and feces containing typhoid bacilli, or cholera spirilla or other similar germs. It is cheap and of some value as a disinfectant, but of course has no place in medicine proper except as a general disinfectant. It is exceedingly inflammable; this property must be remembered or danger may result from disregard of its combustibility—the menstrua being closely related to benzine, we should naturally expect a high degree of combustibility.

SENNINE.—This substance occurs in the form of a white powder with a pleasant faintly aromatic odor and an agreeable sweetish taste; it is readily soluble in water and most of the ordinary solvents. The product is a new one and the result of American enterprise, and is certainly worthy of commendation. Why should we import not only our ideas but even our remedial agents, when American brains and American hands are just as able and competent as those of foreign nationalities? Sennine is composed of phenol and boric acid, and possesses all of the virtues and none of the disadvantages of those substances (see carbolic acid and boracic acid). Both of its ingredients are substances of more than recognized virtue and merit. Lister has very recently declared carbolic acid superior to all other antiseptics and germicides, moreover, he places boric acid nearly as high in the scale of efficiency. In this product, "Sennine," the odor of carbolic acid has been entirely removed; a powder resulting which is not only free from objectionable odor and irritating properties, but is also comparatively non-

toxic; it is readily applied in substance as a dusting powder or as a dry dressing—so much in favor at the present time—and is dispensed in a most convenient metal dusting box for this purpose. It may also be applied in ointment, or, where moist dressings are desired, in solution; a five per cent. aqueous solution being sufficiently strong for general use. Its field of application and usefulness is quite extended; it has been recommended not only in general surgery, obstetrics and gynecology, but in general medicine as well. Reports indicate that it has been used very effectively in numerous conditions, such as otorrhea, otitis, bromidrosis, gangrene, eczemata of various kinds, herpes, laryngitis, thrush, diphtheria and various infectious inflammatory conditions of the naso-pharynx, vaginitis, chancroid, dysentery, erythema, catarrh, typhoid fever, in dermatology and dental surgery; in short, wherever a good, efficient and thoroughly reliable antiseptic can be of any value whatever. It has been used internally in fermentative dyspepsia, in cholera and infectious gastro-intestinal diseases, in gonorrhea, typhoid fever, etc. When administered internally, it is usually given in doses of one to five grains.

Sennine is a comparatively new claimant for honors, consequently its claims must not only be carefully considered, but they must also be substantiated by clinical experience sufficiently extended and sufficiently strong to place its virtues beyond a peradventure. Certainly, in my experience, Sennine has done more than this. I have used it quite frequently as a dry dressing in various

minor surgical cases and have found it very efficacious —superior to Aristol and the various other dry dressings. Indeed I once used it in my *own* case, sprinkling the powder freely over the fresh wound; healing was complete in a very few days *without the formation of a drop of pus.* The effect was most happy.

Prof. Bernays, in a recent letter, to the author of these papers, upon the subject of antiseptics, calls special attention to Sennine as a dry dressing as follows: "Recently an excellent powder for the dry treatment of wounds has been put before the profession in a most convenient form under the name of "*Sennine.*" In a very recent contribution he reports a most interesting and successful operation for the removal of an excessively large cervical fibro-myxo-chondro osteo-sacroma of branchial origin; in this operation the only antiseptic used was Sennine—the result was most excellent, leaving, indeed, nothing to be desired, if results mean anything. To quote his own words: "There was union by first intention; no elevation of temperature and no suppuration. The dry dressing was used and the incision or line of suture thickly dusted with an antiseptic powder consisting of boric acid and phenol. This preparation has recently been introduced by the Dios Chemical Company, and is put up in a tin box with perforated lid. It is called 'Sennine,' and is made by a chemist whose qualifications I know, and I am glad to recommend the preparation, because it is a scientific one, and is put up in such a neat and practical manner,

as to readily answer the requirements of the busy surgeon in private, as well as hospital practice."

He says further of it that: "It affords me pleasure to state that I have used 'Sennine' in my practice with results entirely satisfactory to myself. I say without any hesitation as a dry dressing it is unexcelled. I consider it preferable to aristol, europhen and iodoform, as it is free from toxic and irritating effects as well as unpleasant odor. Five per cent is perfectly soluble in 100 parts of water, making a reliable antiseptic wash as well."

A. H. Ohmann-Dumesnil, late Professor of Dermatology and Syphilology to the St. Louis College of Physicians and Surgeons, and President of the Sections of Dermatology and Syphilography of the American Medical Association and the first Pan American Medical Congress, has used the substance in various dermatoses and as a dressing after such operations as the extirpation of wens or sebaceous cysts. In giving a detailed report of three cases of removal of sebaceous cysts, he says:

"In all of these cases the powder was employed in preference to any solution and care was taken not to apply the powder until the flow of blood had ceased. * * * The powder acts as an effectual barrier to the entrance of any micro-organisms and secures a dry, clear wound, *a condition not so readily obtained from the employment of liquid antiseptics*." He has also used the same substance to advantage in herpes progenitalis and gives his method in full thus:

"The method consists in treating an attack as soon as

it occurs. Each vesicle is opened with a needle knife, thus emptying it of its contents. The wall of the vesicle should not be merely punctured but cut so as not to give it an opportunity to refill. In this manner the possibility of suppuration is avoided. After the vesicles have been opened the following powder should be applied:

℞ Sennine,
Zinci stearat. co., - - - aa ʒij.
M.
Sig. Apply twice a day.

This should be applied twice daily, the proportion of Sennine being gradually increased until it is used pure.

Should the vesicles have ruptured and suppuration set in, the pure Sennine powder should be applied twice daily. In all cases before applying the powder, be there suppuration or not, the parts should be cleansed by letting warm water drip on them, The rapidity of the healing is marked, as well as the disappearance of the subjective symptoms."

He also says further:

"Sometime ago my attention was called to Sennine as a good dry surgical dressing. I have had occasion to use it in my dermatological practice and I find it is a most excellent application in various troubles. It is of value after the removal of sebaceous cyst, insuring a rapid union by first intention. It is also a good preparation in the moist or 'weeping' forms of eczema, not only protecting the inflamed tissue and relieving them from the moisture, but acting as an antipyretic as well.

In furuncle it also acts well after the lesion has been opened and emptied of its contents. It is also excellent (when used as a dusting powder) in many cases of herpes simplex and herpes progenitalis. In fact, as a dry surgical dressing, it is possessed of valuable properties and is in itself a cleanly preparation, devoid of odor.

"It is composed essentially of boracic acid and phenol. It is a good antiseptic and is not irritating. On the contrary it possesses anti-pruritic properties and has the advantage of being susceptible to use in powder, ointment or liquid form. It is soothing to the end terminations of irritated nerves and is destined to acquire a place in dermatological therapeutics."

Yarnall has had an extensive experience with Sennine and in a recent report to the St. Louis MEDICAL REVIEW says of it:

"Since the introduction of 'Sennine' to the profession I have been using it in all appropriate cases and with such satisfactory results that I cannot refrain from recommending it.

"In vaginitis and leucorrhea it is admirable and it has proved especially efficacious in pruritus. An especially obstinate case of the latter with a pregnant woman yielded after resorting to every method that had suggested itself to the writer. Improvement set in at once in this case with the use of Sennine. Local applications were made not only within the vagina on prepared wool, but were also freely applied externally. At this writing the pruritus and irritation is entirely con-

trolled. For ulcerations specific and non-specific it is equally applicable.

"In chancroidal sores it is in my opinion equal to any treatment that can be resorted to,—in short it is valuable in any and all the various antiseptic uses for which it is designed and recommended.

"It is remarkable how largely preparations of this character enter into the practice of every medical man and how many there are offered. The eligible form in which 'Sennine' is presented—its non-toxic and unirritating properties—except in cases of extreme sensitiveness, when it should be mitigated with powdered starch or fuller's earth, and its real therapeutic value must place it at the head of the long list of similar articles."

Dr. C. H. Mastin, of Mobile, who is one of the best known surgeons of the South, has used Sennine and says that "it is a good combination for dry dressing. It is put up in a convenient form and I shall continue to use it." Dr. Mastin's opinion always carries great weight, he being a serious and thorough investigator.

Dr. Morse, the author of "New Therapeutic Agents," says: "I consider Sennine as an ideal antiseptic. It has no faults, chemical or therapeutical. In composition 'a chemically pure product of boracic acid and phenol,' it has the full properties of both drugs. It is not poisonous. It cannot irritate. It effectually destroys all germs. It has a lasting effect. It grows in favor."

Professor Senn has used the substance most successfully as an antiseptic dry dressing in twenty-four cases in his Chicago clinics.

Dr. Heine Marks, Surgeon-in-Chief of the St. Louis City Hospital is preparing a report of forty-eight cases of gun-shot wounds in which the use of Sennine as a dry dressing gave most satisfactory results.

Very recently Dr. Broome read a paper before the Medical Society of St. Louis, reporting an exceptional operation in which Sennine as a dry dressing gave excellent results.

Oatman has used it successfully in rectal ulcerations with stenosis. Roger Williams considers it superior to Aristol, Europhen and other similar preparations. Nold, Scrivner, Harder, Brodnax, Hardesty and indeed many others who have used the product have been uniform in their praise; their experience has been fully confirmed by the results given in the author's own practice, he, at present, using Sennine almost exclusively as a dusting powder and dry dressing.

In view of the fact that antiseptics are numerous and thoroughly reliable ones so scarce (in spite of the optimistic claims of each particular manufacturer) the writer has seen fit to occupy much space in attempting to put forward, though hardly in an adequate manner, this new claimant for antiseptic honors because it seems to him a preparation in which the physician and surgeon will find much of use and value. The present is peculiarly an era of dry dressings and Sennine is certainly gaining in popularity and favor each day—what more the future will do with it remains to be seen. As for the present, certainly its virtues and record sufficiently attest its value.

In a letter recently written to the author upon the subject of antisepsis by Prof. G. W. Broome, of St. Louis, he most aptly says:

"Any physician may see and appreciate the great value of dry dressings in surgical cases. I may go a little further and venture the prediction that the scientific surgery of the near future will not even include the now widely used irrigating vessels in the instrumentarium of the surgeon at all. Instead of irrigations the asepticity of a wound will be secured and maintained by dry sponging. In suppurating cases acepsis will be established by destroying the medium in which the pyogenic micro-organisms grow and multiply by the same means. The availability of any antiseptic is enhanced in proportion to the degree of its inhibitory power. The inhibitory function can be performed perfectly in a dessicated field only. Dessication can only be secured by means of dry, together with hygroscopic dressings. A suppurative inflammation with the presence of pus wherever found in the human body, must be treated by dry sponging, not by irrigation; so that it will only be a little while until the application of powders possessing such power will be a universal practice among progressive surgeons.

"Latterly, I have been using 'Sennine' to dust over laparotomy wounds *and have found it superior in many essential particulars to other antiseptic powders.*"

Silver Nitrate.—$AgNO_3$. Also called *Argentic nitrate* and "*Lunar Caustic*"—the latter term being a relic of the days of alchemy, when the element silver was

known by the name and zodiacal sign of Luna. It is a crystalline substance, soluble in water and possessing the property, in the presence of moisture and heat, of staining organic matter black—this property is made use of in the so-called indelible inks.

This silver salt has marked antiseptic properties. Miquel and Behring, while laboring under the impres sion that corrosive sublimate was the best germicide, placed it next in efficiency to corrosive sublimate—indeed, even superior to that much-vaunted agent in the presence of albumin.

The experiments of Behring seemed to demonstrate that in a solution of the strength of 1:10,000, anthrax spores were destroyed in forty-eight hours. The chief objections are the disagreeable property of indelibly staining organic matter and the fact that its germicidal efficiency is much impaired by the presence of chlorids—that of sodium (NaCl) for instance, which is present in appreciable quantities in such fluids as the urine. This is owing, as has been previously explained, to the formation of comparatively inert and insoluble silver chlorid.

Skatol.—Koch has proven that this substance, even in excess, in water has no germicidal power as far as its action upon anthrax spores is concerned.

Smoke.—This substance possesses inhibitory properties which have been known for ages; these properties have been made use of in the preservation of meats. The preservative properties of smoke are due to the pyroligneous acid and creosote which are contained

therein, although in small quantities. Beu and Petri have shown that salted and smoked meats have contained bacteria undestroyed for six months; after that time, however, they usually failed to give any evidence of vitality. Hence we may conclude that smoke only exercises germicidal power upon long exposure either to its action or to that of its active principles.

Sodic Carbonate.—Na_2CO_3. This substance is more commonly termed *Soda* or *Washing Soda*. It is too familiar a compound to need extended description. Kitasato found that typhoid bacilli were killed in from four to five hours by a 2.47 per cent solution and that the spirilla of cholera were also destroyed by a 3.45 per cent solution.

Sodic Chlorid. —NaCl. This substance is better known as *Salt*—common salt. It is supposed by the laity, and indeed by many physicians, to possess valuable antiseptic properties. This is far from the truth, however; saturated solutions failed to destroy any bacteria (except the spirillum of cholera, which was killed in a few hours) even after prolonged exposure to its action. Experiment has demonstrated the fact that saturated solutions are utterly powerless to destroy or sterilize cultures of the tubercle bacillus even in two months exposure. Miquel has determined that the substance is antiseptic in the proportion 1:6.

Sodic Hydroxid.—NaOH. Better known as *Caustic Soda*. This substance has about the same germicidal activity as the analogous potassium salt (See potassic hydroxid). Miquel has determined that it is antiseptic in the proportion 1:56.

Sodic Di-iodo-salicylate.—This substance usually occurs in white acicular crystals. It possesses antiseptic properties and has been used chiefly as a dusting powder in the treatment of parasitic diseases of the skin. Its use seems to be somewhat limited thus far.

Sodic Di-thio-salicylate.—This substance occurs as a grayish-white powder which is very hygroscopic and is also soluble in water in the proportion 1:1—that is, equal parts. This sulphur derivative of the sodium salt of salicylic acid has antiseptic properties; it has been used locally, as in ozena, and has also been used internally in the treatment of gonorrheal rheumatism and rheumatic fever. When so administered the usual dose is 3 grains given about twice *per diem.*

Sodic Paracresotate.—$NaC_8H_7O_3$. This salt of paracresotic acid occurs usually as a fine, white crystalline powder with a bitter taste; it is somewhat soluble in warm water (about 1:24). It is said to possess antiseptic as well as antipyretic properties and is said to have given successful results when used. The usual dose is 1–20 grains, but as an antiseptic it is given in doses of 1–8 to 1–4 of a grain.

Sodic Sozoiodolate.—$NaC_6H_2I_2OHSO_3$. This compound occurs in the form of well-defined but colorless prisms. The substance is spoken of as an antiseptic; its chief uses so far have been in the treatment of syphilitic ulcers (as a substitute for iodoform), in diseases of the bladder and also in catarrhal affections of the nasal mucous membrane. The salt may be used locally as a dusting powder or in solutions of the strength of one

per cent or else in the form of an ointment of about ten per cent strength.

Sodic Sulphite.—Na_2SO_3. Sternberg obtained entirely negative results from the use of this sodium salt of sulphurous acid. For a long time the sulphites and the hyposulphites enjoyed popularity as germicides of reputed value; but recent researches indicate that they are utterly devoid of germicidal power and hence the sanguine expectations of Polli of Milan have not been realized in this direction. They do not seem to have any material effect upon the process of fermentation and as fermentation without the presence of bacteria is an impossibility, the inference is obvious.

Sodic Sulphocarbolate.—$NaC_6H_5SO_4.2H_2O$. This is the sodium salt of sulphocarbolic acid, and is obtained as a white soluble salt by dissolving sodic carbonate in sulphocarbolic acid. It is closely allied in chemical nature as well as antiseptic activity to the zinc salt of the same acid. (See sulphocarbolic acid, also zinc sulphocarbolate.)

Sodic Tetraborate.—This term is only properly applied to common borax, which is the sodium salt of tetraboric acid. However a different substance is erroneously described under this name by Squibb, Cerna and other writers. This spurious tetraborate is described as a compound resulting from the mixture and application of heat to equal parts of borax, boric acid and water; upon cooling a neutral compound is said to result. It is a well known fact that boric acid yields metaboric acid upon the application of heat to boiling.

It is exceedingly probable then that the action of heat upon the mixture results in the formation of sodic metaborate, which crystallizes out from the resulting liquid, water being simply a vehicle. The reaction could be expressed thus:

Borax. Boric Acid. Sodic Metaborate. Metaboric Acid.

$$Na_2B_4O_7 + H_3BO_3 + \text{heat} = 2NaBO_2 + 3HBO_2.$$

This so called "tetraborate," which is probaly a metaborate, occurs in hard, transparent and clustered crystals with a neutral reaction npon litmus. It is somewhat soluble in water and is said to possess antiseptic properties which are similar to if not greater than those of borax and boric acid. Water at the ordinary temperature dissolves about sixteen per cent. of the substance, and it is this saturated aqueous solution which is used locally in medicine. Menz finds that it has the disadvantage, however, of forming hard crusts on surgical dressings; these hard crusts are objectionable because irritating to abraded surfaces. This is undoubtedly due to crystallization by evaporation of the aqueous menstrum of the solution used. Thus far the substance hss received little recognition.

Sodic Thiophen-sulphonate.—This substance is a thiophen derivative of the sodium salt of sulphonic acid, and is represented by the chemical formula $C_4H_3S.NaSO_3$. It usually occurs as a white, crystalline powder which has been used chiefly as a dusting powder in various diseases of the skin; it is said to be superior, for such use, to beta-naphthol.

Sodic Thio-sulphate.—$Na_2S_2O_3$. This is the sub-

stance commonly and erroneously termed the hyposulphite. Hypo-sulphurous acid is H_2SO_3, and its sodium salt would be Na_2SO_3—the only correct chemical formula for sodic hyposulphite. The substance commonly called the hyposulphite or "hypo" is really the sodium salt of thio-sulphuric acid $H_2S_2O_3$.

The so-called hyposulphite has been vested with antiseptic powers in the minds of physicians ever since the day of the extravagant claims of Polli of Milan—indeed even earlier. The experiments of Arloing, Cornevin and Thomas prove it, however, to be utterly devoid of germicidal power. Miquel has determined that it is antiseptic in the pproortion 1:3—this indicates feeble powers. (See sodic sulphite.)

Solutol.—This substance belongs to the same class of bodies as creolin, cresin, lysol, saprol, solveol, etc. It is a combination of cresol (cresylic acid) and sodic cresylate; it contains about sixty per cent. of cresylic acid, one-fourth of which is free and the remaining three-fourths being combined with sodium to form the cresylate. Cresol itself is insoluble, and sodic cresylate is therefore used to render it soluble, otherwise it would be practically useless. We may therefore consider solutol to be an alkaline solution of sodic cresylate in excess of so-called cresylic acid (cresol.) In this respect it is markedly similar to, indeed almost identical with cresin, which see.

It makes a very effective preservative for cadavers, and hence may be service in the dissecting room. It is also of great use for the disinfection of closets, sinks,

infected bed clothing, infectious sputa or other such discharges, etc. Its caustic and strong alkaline nature, precludes its use in surgery, either as an application or even in surgical dressings. It has played no part in the medical literature of the past year.

Solveol.—This substance is analogous to solutol, being a solution of cresylic acid (cresol) in sodic cresotate. It usually occurs as a dark liquid with a little odor and a *neutral* reaction; it is soluble in water While slightly caustic and irritant it is not as markedly so as solutol. It is also not so greasy as either creolin or lysol. It is usually used in strengths of one-half to one per cent., being slightly irritant in such proportion. Hueppe seems to think that it is superior to carbolic acid, but this opinion does not seem to be upheld by the surgical world, at least it has been unable to supplant carbolic acid in surgery.

Sozal.—This substance is the aluminum salt of para-phenyl-sulphonic acid (also termed sozonic acid). It is somewhat allied to Alumnol, the aluminum salt of naphthol-sulphonic acid. It occurs in the form of crystals, which have an astringent taste and a slight odor of carbolic acid; it is soluble in water and does not seem to decompose very readily. It has been recommended for use in surgical dressings, although it is but a feeble antiseptic. If one may judge from its disappearance from medical literature, it seems to have practically passed from use.

Sozoiodol.—This substance is also termed *Di-iodo-*

para-phenyl-sulphonic acid. Squibb gives the following method for its preparation:

"About two parts of crude carbolic acid are added very slowly to one part of strong sulphuric acid. The reaction raises the temperature to about 110°C. and continues for two or three days, when para-phenyl-sulphonic acid (sozonic acid) is formed. Any excess of carbolic acid is removed and then iodine is added to form this sozo-iodolic acid (sozo-iodol)."

It occurs in acicular prisms which are free from odor and readily soluble in alcohol, water and glycerine. It has been employed as a local antiseptic in diseases of the skin and naso-pharynx; also in venereal diseases and wherever iodoform is applicable. It is used locally as a dusting powder, or in gauze, or in collodion, or in solution in strengths of 5 to 20 per cent. The aluminum, ammonium, lead, potassium, sodium, zinc and mercury salts of this acid are employed more frequently than the acid itself. The sodium salt seems to be the most favored derivative thus far; it occurs in bright, somewhat prismatic acicular crystals, which are odorless and employed either in substance or else in 5 to 10 per cent. aqueous solutions. Guttmann reports thirty cases of pertussis in which nasal insufflation of the substance gave good results.

Witthauer has employed the mercurial salt in powder, emulsion and ointment with what appears to be good effect.

Dräer claims that preparations of this substance, and of the free acid and mercurial salt in particular, possess

marked disinfectant action when brought into contact with cholera spirilla, and also that sufficient strength of solution and length of exposure is able to completely prevent their growth. This, however, Hueppe directly contradicts. Suffice it to say that the substance is not growing in favor.

Steresol.—This is the name for an antiseptic varnish introduced into therepeutics by Berlioz. It is recommended for use in diphtheria and in certain skin affections. Two formulas for the substance are given, the first of which is from Blanc.

	Grms.
Gum Lac.,	5.
Gum Benzoin,	5.
Balsam Tolu,	5.
Cryst. Phenol.,	1.5

Alcohol sufficient to dissolve.

II.

	Grms.
Purified Gum Lac.,	270
Purified Gum Benzoin,	10
Balsam Tolu,	10
Cryst. Pheno	180
Oil of Cassia,	6
Saccharin,	6

Alcohol sufficient to make 1 litre.

No clinical reports have been received in regard to this preparation as yet; it is therefore impossible to decide its status.

STYRACOL.—This substance is the cinnamic ether of guaiacol, and is produced by heating cinnamyl chlorid and guaicol together. It has the chemical formula $C_6H_5.C_6H_4.OCH_3.CH:CH.CO.O$. It occurs as a crystalline needle-like powder. It was suggested as a local antiseptic, also internally in pulmonary tuberculosis, in diseases of the gastro-intestinal tract, in chronic vesical catarrh, and in gonorrhea. Experience has hardly justified these expectations, however, and like many others of its therapeutic brethren it seems to have died the death.

STYRON—This substance is a compound of Peruvian balsam and liquid storax. It has been used locally in ulcerations, and has been suggested for administration in cholera. It has been employed in the spray in a strength of four per cent.; in solution in the strength of eight per cent., and for introduction into serous cavities, such as those of the chest and abdomen, in solutions of varying strengths from 1:200 down to 1:50.

It is but little heard of recently.

SULPHAMINOL.—Alto termed *Thio-oxy-di phenyl-amiu*. It is obtained by the action of sulphur upon the salts of meta-oxy-di-phenyl-amin. It occurs as a light, pale-yellow, odorless and tasteless powder, which is insoluble in water but freely soluble in the alkalies, acetic acid and alcohol. Its solutions retain the pale-yellow color. It seems to possess the power of checking the formation of pus to some degree, and this is considered by some its chief claim to recognition in therapeutics; although its antiseptic power, if it has any at all, is

very weak. It has been used in powder in wounds, and has been insufflated into the nasal fossae and sinuses of that region with some apparent benefit. It has been recommended in gastro-intestinal disorders on the supposition that the digestive fluids decompose it into carbolic acid and sulphur. However, it is used chiefly as a local application, as are also its derivatives sulphaminol-creosote, sulphaminol-eucalyptol, sulphaminol guaiacol and sulphaminol-menthol. When administered internally it is usually given in single doses of four grains, or daily doses of fifteen grains.

Wojtaszek conducted a series of experiments upon rabbits in order to test the claims of the advocates of sulphaminol. After such experimentation he concludes that "sulphaminol is devoid of any physiological action. As regards its alleged antiseptic properties, they also seem to be about *nil.*"

Squibb says that the substance has not been in general use during the past year, and that even during the year before last few reports concerning it appeared in medical literature.

Sulphocarbolic Acid.—$HC_6H_5SO_4$. Also termed *Phenol-sulphonic acid*, *Sozolic acid* and *Aseptol.* It is formed by the action of concentrated sulphuric acid upon phenol (carbolic acid). Icthyol is sodium or ammonium icthyo-sulphonate, a derivative of this acid; it is a natural product, however. The acid itself is not so much used in medicine, its derivatives being in commoner use; the chief of these are the sodium and zinc salts (which see).

Sulphume.—This substance has been also called, "Pure Liquid Sulphur" (!) It is nothing more nor less than an aqueous solution of the higher sulphids or sulphhydrids of sodium and potassium saturated with sulphur, with traces of the sulphids of calcium and magnesium. It is very ingenuously but not ingeniously recommended by the manufacturer for skin diseases, open sores and ulcers, ulcerated throats, diphtheria "and other affections." It is almost totally devoid of germicidal power, however.

Sulphur Di-oxid.—SO_2. This substance is erroneously termed "*Sulphurous acid*" and "*Sulphurous acid gas.*" It is produced by the burning of sulphur—that is, by its oxidation, thus:

$$S + O_2 = SO_2.$$

It is very extensively used for purposes of fumigation, but has little or no use in medicine or surgery proper.

Sternberg (1880) found that this substance, which is a gas, disinfected dried vaccine virus exposed for twelve hours on ivory points to the action of an atmosphere containing one volume of the gas. The liquid virus, however, exposed in a watch-glass, was disinfected by one-third of this amount.

Sternberg (1885) found that pus micrococci were killed by an exposure for eighteen hours to the action of a dry atmosphere containing twenty volumes of the gas (SO_2)—four volumes per cent failed. Experimental data force us to the inevitable conclusion that this substance, like chlorin, is much more active as a germicide

in the presence of moisture. Moisture, as is the case with chlorin also, causes a bleaching action as well as an antiseptic one. An aqueous solution of the gas will give true sulphurous acid (H_2SO_3) thus:

$$SO_2 + H_2O = H_2SO_3.$$

The presence of moisture is essential to this substance (SO_2) if germicidal power is to be exercised by it. Indeed, in the pure state *anhydrous sulphur di-oxid does not destroy spores, even when the gas is liquefied by pressure.* Moisture is essential.

Thinot (1890) has come to the conclusion that the specific germs of tuberculosis, glanders, farcy of cattle, typhoid fever, cholera and diphtheria are destroyed by an exposure of twenty-four hours to an atmosphere containing the gas developed by the combustion of sixty grains of sulphur for every cubic metre.

The American Public Health Association in directing the use of this substance as a disinfectant recommends that the infected articles be "exposed for twelve hours to an atmosphere containing at least four volumes per cent of this gas *in the presence of moisture.*"

SULPHURIC ACID.—This substance is too familiar to need description—suffice it to say, in this regard, that its chemical formula is H_2SO_4.

Koch (1881) found that anthrax spores grew after exposure to a one per cent solution for twenty days.

Sternberg (1885) demonstrated that a four per cent solution failed to destroy the vitality of the spores of the *Bacillus subtilis* in four hours.

Seitz found that the dejecta of typhoid patients, when

mixed with equal parts of the disinfecting solution, were sterilized by a five per cent solution in three days. The evidence in the case forces us to the conclusion that sulphuric acid possesses considerably less germicidal power than carbolic acid.

SULPHUROUS ACID.—H_2SO_3. Sternberg (1885) found that micrococci were destroyed in two hours by 1:2000 by weight of sulphurous anhydrid (SO_2) added to water. He also demonstrated that pus cocci fail to grow in an aqueous solution of the strength 1:5000.

De la Croix determined that one gramme of sulphur di-oxid when added to two thousand parts of bouillon prevented the development of putrefactive bacteria and finally destroyed their vitality after a time.

Kitasato found that typhoid bacilli were killed .28 per cent and cholera spirilla by .148 per cent in five (?) hours.

TANNIC ACID.—$C_{14}H_{10}O_9$. This substance, also called *Tannin*, is too familar to physicians to need description. It is more commonly used as a tonic, hemostatic and styptic but experiments demonstrate that it possesses more or less antiseptic activity. A twenty per cent solution failed, after two hours exposure, to destroy the spores of *Bacillus anthracis* and *Bacillus subtilis*. Abbott however demonstrated that a solution of the strength 1:400 (.25 per cent) destroyed micrococci. Kitasato found that 1.66 per cent destroyed the typhoid bacillus in five hours and 1.5 per cent effected the same result in the same time in the case of cholera spirilla.

Miquel has determined that it is antiseptic in the proportion of 1:207.

Tartaric Acid.—$H_2C_4H_4O_6$ or $C_2H_2.(OH)_2.(COOH)_2$. This substance, which is manufactured from grape-wine deposits (argol), is used in medicine and the arts. It is sufficiently common to need no description. The substance seems to be about equal to tannic acid in antiseptic activity.

Abbott found that micrococci were killed in two hours by a solution of the strength 1:400. As was also the case where tannic acid was used, a twenty per cent solution failed to destroy the spores of *Bacillus anthracis* and *Bacillus subtilis*. Hansen has shown however that its germicidal power is limited to a comparatively small number of species—indeed whole species of micro-organisms are not only unaffected by tartaric acid but even actually favored by it.

Terebene.—$C_{12}H_{16}$. This substance is supposed to be a modification of terpene, produced by the distillation of oil of turpentine with sulphuric acid; it is supposed to contain camphene, cymene, terpilene and borneol. It is a light yellow liquid with the odor of freshly-cut pine wood, or the odor of thyme. It is somewhat soluble in ether and alcohol but practically insoluble in water. It is said to be an agreeable antiseptic, a five per cent solution is said to have made a very serviceable surgical dressing. It has been used by inhalation in bronchial affections and in pulmonary tuberculosis.

It may be used internally in capsules or in emulsion

in doses of 4 to 6 minims; or externally in five per cent solutions.

TERPINE.—$C_{10}H_{18}(OH)_2$. Aq. The hydrate of terpine is obtained by the action of alcohol, nitric acid and oil of turpentine upon each other. It occurs in white, odorless, rhombic crystals with a faintly aromatic taste. It is soluble in alcohol and boiling water but only moderately so in cold water, benzene, turpentine and carbon disulphid. It has antiseptic and expectorant properties, it is said. It has been recommended for use in bronchitis and whooping-cough. It is given in doses of 2 to 6 grains, preferably in tablets or in alcoholic or syrupy mixtures.

THALLINE.—$C_9H_{10}N(OCH_3)$. This substance is also termed *Tetra-hydro-para-methyl-oxy-chinolin* and *Tetra-hydro-para-chinonisol.* It is formed by heating acrolein and para-amido-anisol together with some oxidizing agent. At ordinary temperatures it is a liquid which forms, when cooled, a yellowish-white, crystalline powder with a bitter, saline taste and a peculiar somewhat aromatic odor. It is soluble in water; its two chief salts, the sulphate and the tartrate, which are used in medicine, are soluble in water and slightly so in alcohol. Wood speaks very briefly but also very unfavorably of the substance. It has been used in gonorrhea, in one and a half per cent injections and two per cent bougies, with apparent success.

THILANINE.—This substance is a sulphuretted lanolin produced by the action of sulphur upon lanoline and containing about three per cent of sulphur. It is a yel-

lowish-brown substance resembling vaseline and devoid of irritating properties. It has been used locally in dermatology, being designed to replace ichthyol and thiol.

Fox, after experience with the medicament, concludes that it possesses no single advantage over the remedies commonly used. It is objectionable, however, on account of its color, odor and high price. It seems to have received little or no attention during the past year and has probably passed out of use.

THIOL.—Thiol is a mixture of sulphuretted hydrocarbons, it is an artificial substance designed as a succedaneum for ichthyol; this latter substance is obtained by the distillation of a bituminous oil, it contains ammonium and probably also sodium ichthyo-sulphonate,—it is used chiefly in dermatology, having no active germicidal properties though said to have the power of arresting the growth of bacteria. Thiol occurs in two forms; one, a liquid, which exists as a thin, brownish extract slightly heavier than water and is not the purified product, it is therefore cheaper and oftener used; the other occurs as a fine brown powder, or else in scales. It is soluble in water, especially in the presence of glycerin. The substance is chiefly used by dermatologists and gynecologists. Reports as to the results of its use indicate that it is free from odor and irritating properties, does not cause bleeding from raw and eroded surfaces, promotes absorption of effusions—and indeed has such advantages over ichthyol itself that it bids fair to displace the latter substance. Thiol may be given intern-

ally in doses of one and a half grains; locally it may be applied as a dusting powder, or else in ointment or else in solutions of 10 to 50 per cent strength.

THIOPHEN.—C_4H_4S. This substance is a sulphur derivative of benzene. Indeed Meyer has pointed out the fact that it occurs in all of the commercial benzenes derived from coal-tar. It may be isolated by agitation with one-tenth volume of concentrated sulphuric acid. The substance occurs as a clear, colorless and volatile oil which is insoluble in water.

Thiophen itself has been but little used in medicine, but its derivatives, lead and sodium thiophen-sulphonate (which see) and thiophen di-iodid, have been favorably reported on from Kaposi's clinic in Vienna.

Thiophen di-iodid ($C_4H_2I_2S$) occurs in beautiful, small, crystalline tablets which are volatile at ordinary temperatures and which are also insoluble in water; the compound has been used as a substitute for iodoform, being employed in all conditions in which iodoform would be considered indicated. Hock, of Vienna, says that its use in the powder in surgical dressings seems to retard the formation of pus and to prevent the occurrence of of exuberant granulation. It is used in the form of a dusting powder, or else in gauze. Its freedom from objectionable odor and its non-toxic and non-irritating properties have been demonstrated by clinical experience.

THIORESORCIN.—$C_6H_4(OS)_2$. This substance results from the combination of resorcin, sodic hydroxid, sulphur and hydrochloric acid. The product occurs in the

form of a flocculent, grayish-white, non-irritating, tasteless and odorless powder which is insoluble in water but slightly soluble in alcohol and ether. It has been suggested and employed as a substitute for iodoform and has been used as a dusting powder, especially in the treatment of ulcers of the leg.

THYMOL.—$C_{10}H_{13}OH$. This substance is obtained from the volatile oils of thyme and other plants. It occurs in large, transparent plates or in acicular crystals which are insoluble in water but soluble in the fatty and essential oils. It has been used by inhalation in pertussis and various pulmonary affections; it has also been employed internally in various gastro-intestinal diseases and in rheumatism. It is said to have given good results in the treatment of wounds, skin diseases and various affections of the mouth.

This product was introduced into medicine by Ranke of Halle, in 1878, and was much lauded on account of its comparative freedom from poisonous and irritating properties, but clinical experience has in nowise warranted the brilliant expectations, they have not been fulfilled. A five per cent solution does not destroy anthrax spores, even in fifteen days' exposure to its action, as has been demonctrated by Koch; but their development is somewhat restrained by 1:80,000 he states. Yersin found that the substance itself required three hours to destroy the tubercle bacillus. Behring after careful investigation, pronounces that it possesses four times *less* germicidal power than carbolic acid, and yet Ranke fondly believed it to be a formidable rival of the

latter. Miquel has determined that it is antiseptic in the proportion of 1:1340.

TIN CHLORID.—This substance, in one per cent solution and acting for two hours, destroyed the bacteria of of putrefying bouillon, but an .8 per cent solution failed to accomplish this.

TOBACCO SMOKE.—Tassinari demonstrated that tobacco smoke possesses the power of restraining the development of bacteria—especially certain species, as Friedlaender's bacillus and the spirilla of cholera, which fail to develop after exposure for half an hour to an atmosphere of tobacco smoke.

TUMENOL.—This is a comparatively new compound which is produced by the treatment of the unsaturated hydrocarbons of mineral oils with sulphuric acid, and is closely allied to ichthyol. It occurs as a dark-brown fluid which Neisser, of Breslau, seems to consider an efficacious compound. He says that the substance and its compounds, whose action seems to be chiefly superficial, owe their virtues to their strong reducing properties rather than to the sulphur in their composition, which latter is true in the case of ichthyol. It has been recommended in pruritus, moist eczemata, etc. It has, however, no antiparasitic or germicidal powers and hence is of no service in erysipelas. But little has been heard of the substance in this country as yet.

VALERIANIC ACID.—$HC_5H_9O_2$ or better $C_4H_9.COOH$. This acid is an oily, colorless, liquid with a penetrating and characteristic odor; it is but slightly soluble in water but is soluble in alcohol. It is found in valerian

and angelica root but is generally prepared by the oxidation of amyl alcohol. Koch found that a five per cent solution failed to destroy anthrax spores even after five days' exposure.

XYLOL.—C_8H_{10}. Also termed *Xylene* and *Di-methyl-benzene.* This substance, as its chemical formula indicates, is a hydrocarbon and resembles benzene. It is said to possess antiseptic properties and application has been made of this fact, especially in the treatment of variola. The dose, when adminsstered internally, is 30 to 45 grains given in wine.

ZINC CHLORID.—$ZnCl_2$. This substance, which is used in concentrated solution as an escharotic or caustic, also possesses antiseptic powers. Koch found that it had little or no effect upon anthrax spores, however, for such spores germinated even after thirty days immersion in a five per cent solution. A five per cent solution successfully destroyed the spoies of *Bacillus subtilis.* A two per cent solution destroyed pus cocci in two hours while a .5 per cent (1:200) solution destroyed the *Micrococcus Pasteuri* in the same time. Miquel has determined that the substance is antiseptic in the proportion of 1:526.

ZINC-MERCURIC CYANID.—$Hg(CN)_2.4Zn(CN)_2$. This substance occurs as a white powder which is practically insoluble in water. It has been highly recommended as a non-irritating antiseptic but its use has not become general. Until recently it was the favorite antiseptic used by Sir Joseph Lister, the "Father of Antiseptic Surgery"; more recently, however, he has repudiated all

antiseptics with the exception of carbolic acid—this he deems the antiseptic *par excellence*. The chief objection to zinc-mercuric cyanid is its feeble germicidal power, owing what virtue it possesses to its inhibitory power. (See "Mercury.")

ZINC SOZOIODOLATE.—This substance is the zinc derivative of sozoiodol (which see). It occurs in the form of acicular crystals which are soluble in water in the proportion of 1:20. It has been used in acute and chronic blenorrheas and also in acute inflammatory conditions of the naso-pharynx. In gonorrhea it is employed in aqueous solutions of strengths of .5–1.5 per cent, to which either laudunumn or salicylate of bismuth may be added.

ZINC SULPHATE.—$ZnSO_4$. This substance occurs in crystals or crystalline masses which are readily soluble in water. The product is used chiefly as a mineral astringent or an irritant emetic. Some physicians have attributed antiseptic or germicidal powers to it. Koch found that anthrax spores germinated even after ten days immersion in a five per cent solution. Micrococci from an acute abscess resisted the action of ten to twenty per cent solutions even after exposures of two hours—the *Micrococcus tetragenus* was killed however. A careful consideration of all of the experimental data at our command leads us to the conclusion that the substance has very feeble, if any, germicidal power.

ZINC SULPHOCARBOLATE.—This substance is the zinc salt of sulphonic acid, also termed sulphocarbolic or phenyl-sulphuric acid. (See sulphocarbolic acid). This

salt was at one time highly vaunted as an intestinal antiseptic. Koch found that a five per cent solution failed to destroy anthrax spores even after five days exposure—the sodium compound was equally worthless, even when applied for a greater length of time.

Zinc Sulphydroxid.—$Zn(SH)_2$. Theoretically this substance is the hydroxid in which the oxygen of the radical hydroxyl has been displaced by sulphur. Zinc sulphydroxid occurs as a white solid which readily decomposes in the dry state and is therefore frequently preserved by immersion in water. It has been employed both internally and externally. Its use in external treatment has been chiefly in such conditions as psoriasis, eczema and various dermatoses of a vegeto-parasitic character. It can be used externally in the form of an ointment of the strength of ten per cent. Internally it is administered in doses of one-half to two grains, usually in pill form.

VIII.—Their Use and Value in General Medicine.

What have the principles of general antisepsis done for general medicine? Have not their far-reaching influences been felt even here? To-day the modern science of bacteriology is about to revolutionize modern medicine and its principles—indeed we seem upon the eve of a dawn of the elaboration of a specifiic and radical treatment for disease, infectious diseases at least. In some cases this seems to have been accomplished al-

ready while in others a vast stride has been made in such direction by the demonstration, isolation and study of the various specific organisms upon which the etiology of these diseases seem dependent. While much has been accomplished in this field, it is chiefly in the sphere of preventive medicine, of praphylaxis, that the harvest has proven richest and most abundant. In the case of pulmonary tuberculosis, one of the most fatal as well as common of all diseases, the specific cause of the disease has been discovered, isolated, cultivated and studied. This has led to the demonstration that infection in many cases is largely due to the dessication and dissemination of tuberculous sputa as an impalpable powder.

A proper appreciation of the infectious and dangerous nature of the sputum has led to its destruction or sterilization. The result of this has been seen in some localities, where extended observations were made, in a reduction of the death-rate of the disease. When we consider the extent of the disease and its essentially fatal character, we can readily appreciate the fact that even a slight reduction in the mortality is as significant as important, indicating as it does the possibility of more than a slight saving of human life the world over. While the disease itself is by no means thoroughly amenable to treatment, yet its inception has been to some extent avoided by the destruction or sterilization of the infectious discharges (sputa) from those thus affected. Moreover attempts at internal and local treatment of the diseased condition, although hardly brill-

iantly encouraging, have not been altogether devoid of result. Of course in all treatment it must constantly borne in mind that the destructive action of the blood and tissues upon parasitic organisms is appreciably decreased by conditions of mal-nutrition and depressed vitality; or by surroundings unfavorable to the most healthy development of the body and its organs and tissues. By improving nutrition and placing the patient in the most favorble hygienic conditions which are *per se* least favorable to micro-organic development, we increase the germicidal power of the blood and tissnes and their toxicity for tubercle bacilli as well as other bacteria.

To hygiene, to quarantine, to sanitary science, antisepsis and bacteriology (its logical outcome) have proven of the utmost value—indeed upon this rock are they now founded. Typhoid fever, Asiatic cholera and various other epidemic and infectious diseases have had their virulence comparatively circumscribed by rigid adherence to the dicta of antisepsis, especially by the complete disinfection of stools and other infectious discharges from those afflicted. This has been of decided value; when one is unable to control an infectious disease itself, it is of the utmost importance and value to be able to control the *spread* of the disease. It is difficult to estimate the absolute value of such power, because such value depends upon the casualties and fatalities *averted*, therefore it must remain an unknown yet indubitable quantity or factor. To what did we owe our freedom from the terrible scourge of cholera a few

years ago but to the prompt institution of rigid sanitary and hygienic—that is, antiseptic—precautions? Indeed scientifiic men are so familiar with the abundant and practical results of the application of antiseptic principles in preventive medicine that is hardly seems necessary to do more than direct attention to them. Certainly they are as manifest as the successes of the use of antiseptics in various traumatisms and in the treatment of localized infectious conditions where accessible to local treatment.

Moreover bacteriology, the legitimate offspring of antisepsis, has also added greatly to the precision of diagnostic skill and science. What nosological chain of evidence is now complete and positive, in tuberculosis, that is devoid of a demonstration of the presence of the specific bacillus in the morbid secretion? What diagnosis of Asiatic cholera is a completed scientific entity at the present day unless the presence of the characteristic spirilla in the alvine discharges has been demonstrated? How indeed may we clearly and positively differentiate between diphtheria and several other infectious, inflammatory, membranous or pseudo-membranous diseases of the naso-pharynx except by a bacteriological demonstration of the presence or absence of the Klebs-Loeffler bacillus?

In the earlier days of even modern antisepsis substances were frequently employed which later and riper experience has proven devoid of value. The beginning, of all systems are necessarily crude, it is the oft-repeated story of *per aspera ad astra.* In the utter absence of

precise knowledge concerning the nature of the infecting agent, or germ, or its habits as well as habitat, it was not surprising to find the sanitarian devoting himself to futile efforts at destruction of imaginary foes with weapons almost as imaginary. For this same reason he frequently neglected to attack the much more material and infectious pathogenic principles of such things as tuberculous sputa or typhoid or choleraic excreta. We have now learned however that even if pyogenic and pathogenic bacteria do exist in the air (which is not to be doubted) the spray, as Stimson has amply shown, is thoroughly incapable of effecting their destruction. By far the greater danger of infection lies in the transfer of germs directly to the wound surface or other focus of infection by means of infected hands, instruments or dressings. Indeed in many cases, formerly, the physician or surgeon was himself the unsuspected and unconscious source of infection. Now however everything unsterilized is looked upon as a *possible* source of infection.

The vital resistance of bacterial organisms to various agents differs within certain limits for the various species; some exhibiting special susceptibility to special agents, for example that of the septic micrococcus to alcohol and of the *Bacterium termo* to boracic acid. There is therefore certainly some rational basis for the supposition that the various pathogenic germs may likewise exhibit similar susceptibilities to various agents administered medicinally with a view to the destruction of such germs, or rather to a prevention of their devel-

opment. The antiseptic value of the substances so tested depends largely, indeed entirely upon their power to prevent the multiplication and proliferation of bacteria. This does not necessarily imply *germicidal* power, which it would hardly be within the bounds of reason to expect in internal administration. Indeed Sternberg has claimed that it is possible that the virture of mercuric chlorid and iodid in syphilis may be due to the *restrictive* power of even the small quantities of the drug exhibited. It would be impossible to introduce sufficient to *kill* the germ but he thinks it plausible at least that a sufficient quantity may be ingested to restrict its growth and development. Some agents which do not actually *kill* micro-organisms nevertheless possess considerable restrictive power and by virtue of this property become valuable antiseptics, this is especially true of boracic acid.

Clinical experience has demonstrated the value of various antiseptics which have been used experimentally in the treatment of various diseases in which there was reason to even suspect the presence of specific organisms. Indeed there are few practitioners who have not employed these agents internally for the cure of various forms of disease. In some instances their effect has been more or less prompt and satisfactory; in others probably only negative results have been attained while in a third class perhaps only toxic and untoward developments have arisen. In view of this diversity and varience in both results and opinions perhaps a discussion of the proper uses and limitations of antiseptic

remedial agents, however brief or imperfect, may not be entirely out of place. Let us look at our facts in the light of the developments, established by both experiment and experience, of the past few years. It has been demonstrated beyond doubt that most of the infectious diseases at least are due to (*a*) specific organisms or (*b*) substances produced by the action of specific organisms; and that most, if not all, of these diseases are accompanied by more or less pyrexia. In many of these cases the specific organism has been isolated and determined, as is the case with the following:

Morbid Conditions.	Micro Organisms.
Suppuration.	The various pus cocci such as *Staphylococcus pyogenes aureus*, *albus*, *citrus* and the *Streptococcus pyogenes*.
Gonorrhea.	The *gonococcus* of Neisser.
Anthrax.	*Bacillus anthracis*.
Tuberculosis.	" *tuberculosis*.
Leprosy.	" *lepræ*.
Glanders.	" *mallei*.
Typhoid fever.	" *typhosus*.
Tetanus.	" *tetani*.
Influenza.	" *influenzæ*.
Diphtheria.	" *diphtheriæ*.
Specific croupous pneumonia.	*Diplococcus pneumoniæ*.
Asiatic cholera.	*Spirillum choleræ*.
Relapsing fever.	*Spirochaete Obermeieri*.
Epidemic dysentery.	*Ameba dysenteriæ*.
Erysipelas	*Streptococcus erysipelatis*.

Then too certain other diseases such as variola, rubeola, scarlatina, yellow fever, typhus fever, syphilis, Oriental plague and several intestinal diseases are also infections in nature and doubtless have specifiic organisms which have not as yet beén isolated. Let us glance briefly at these conditions.

In the case of suppuration the virtue and value of antisepsis is peculiarly marked. In a properly conducted treatment of a localized and accessible condition the formation of pus is now practically as rare as it was formerly common. Indeed as Gerster says, at the present day infection and suppuration in a fresh wound are due to technical faults or else errors of commission or omission on the part of the professional attendant in charge.

Anthrax and glanders are more commonly confined to the lower animals and hence have little interest to us in a consideration of the method and results of antiseptic treatment.

In the more modern and successful treatment of gonorrhea the tendency is to the use of irrigant antiseptic solutions of boracic acid, mercuric chlorid, potassic permanganate and hydrogen peroxid. In such cases the results given have been more than satisfactory. Indeed sterilization of the lower genito-urinary tract has been accomplished, it is even claimed, by the internal administration of such remedies as oil of wintergreen or boracic acid. Johnson had proven the appearance of boracic acid in the urine ten minutes after its administration by the mouth.

In the case of influenza, variola, rubeola, scarlatina, yellow fever, typhus fever and relapsing fever little or no benefit has been ascribed as yet to internal antiseptic medication, except in the case of influenza which some claim is distinctly modified by the inhalation of vaporized volatile antiseptics. In scarlatina also antiseptic inunctions in the latter stage have lessened the chances of infection of those coming in contact with the patient.

Epidemic dysentery, so long beyond the control of the physician, has at last been found more or less amenable to antiseptic rectal injections, especially of aqueous solutions of argentic nitrate.

Diphtheria is now recognized as an infectious disease of a local nature whose general symptoms are due to secondary absorption of the products of vital activity on the part of the germ. Its treatment is essentially antiseptic, being directed against the germ lodged in the membrane. The results of such treatment are so obvious that we need hardly do more than refer to them. The same is also true of erysipelas, whose streptococcus seems to be specially susceptible to the influence of carbolic acid. In Asiatic cholera it has been noticed that the spirilla are especially susceptible to the effect of the mineral acids, even in dilute solutions. Advantage has been taken of this fact in the treatment of the disease and it has also been combined with intestinal irrigation.

In the case of tetanus Dr. Schwarz, of Padua, cured a boy of the disease by means of the injection of an antitoxin which had been prepared by Tizzoni and Cattani

from the specific bacillus. Schwartz likewise refers to three other similar cases which had been treated by Italian physicians in a similar manner with the successful result in each case. Fraenkel had a similar experience in diphtheria.

It is now established beyond doubt that typhoid fever is caused by a specific organism introduced from without. Eberth found the bacillus present in the spleen, lymphatic glands and portions of the intestinal tract in twelve out of twenty-three cases, Koch in fifty per cent and Meyer in sixteen cases out of twenty. Lucatello reproduced the disease in ten out of thirteen cases by inoculation with blood from the spleen of a diseased animal. Neuhaus found the bacillus in the rose maculæ in nine out of fifteen cases. The chief seat of the disease is in the intestinal tract. It hardly seems rational to claim to be able to *kill* the germ under such surroundings, but can we not sweep the fecal matter from the bowel and by the use of proper antiseptics prevent the development and proliferation of the germ within the intestinal tract? The experiments of Fortchinskey are interesting in this connection. He used from ten to fifteen grain doses of boracic acid in two hundred and forty cases of typhoid fever during an epidemic; he was successful in two hundred and thirty-one cases—about ninety-six per cent. He claims that in the first three or five days fever and diarrhea diminished, tympanitis almost disappeared and the stools became normal in character.

It is hardly necessary at the present time to offer

proofs of the existence of ptomaines and toxalbumins, this has long since been done by many competent and reliable observers. Indeed such substances may be real causative factors in disease or in the causation of dangerous and disagreeable symptoms. Such ptomaines or toxalbumins may originate either externally or internally, in either event their ingestion and absorption are more or less promptly followed by various acute phenomena resembling ordinarily the profound symptoms of acute alkaloidal poisoning. In many cases the disease may be primarily local but soon becomes constitutional, a result of the secondary absorption of the products eliminated by the germ in its life history. And the manifestations of this secondary or systemic infection are often more alarming and more dangerous than those of the primary local infection. After this general infection has taken place the local use of antiseptics is useless except iu the attainment of a purely local result. The disturbing element is no longer circumscribed, it has now penetrated within the portals of the circulation whither we can hardly follow it, for the agent which by its toxic power has paralyzed the nervous system and threatens every function is quite beyond thh reach of germicides—it is amenable to no antiseptic. The cause is not an organism whose vitality may be destroyed, it is a definite compound whose physiological effects must be combated or whose chemical autonomy must be destroyed. After ptomaines, leucomaines or toxalbumins are formed they can hardly be antagonized by germicides, the germ must be destroyed *before* elaborating

the substances. In other cases perhaps the germ itself may enter the circulation, leaving the site of primary infection; it is then inaccessible and proof against attacks of this nature. If in this latter case the future treatment of infectious disease is to be directed to specific germs rather than to the resulting phenomena we shall be forced to rely not upon mechanical destroyers but upon proteids or alkaloids which are either chemically or physiologically antagonistic, as well as to institute treatment with a view to an increase of the vital resistive power of the tissues and fluids. Here is the field of the medicine of the future. Germicides are only of value in so far as they destroy germs and prevent future elaboration of toxic products. Clearly then the inference is obvious—action must be taken sufficiently early to destroy the germ and render impossible secondary infection by absorption of toxic products.

In such diseases as are dependent upon secondary infection our main reliance as yet is to be placed in those remedies and measures which support and stimulate the vitality of the patient and promote his nutrition—"*da robur, fer auxilium.*"

It can be positively stated that fermentative or putrefactive micro-organisms do not exist actively in the intestinal tract when its secretions are normal. Kurlow and Wagner have proven conclusively that constant or specific microbes do not exist in the stomach and that those which do enter it with the ingesta are only accidental abd temporary residents for they cannot live in the normally acid contents of that organ. In their

opinion the normal gastric juice is indeed an exceedingly strong germicidal agent and when in full and normal activity destroys all others than the most prolific and tenacious germs, such as the bacilli of tuberculosis and anthrax; certain staphylococci also seem to be able to withstand its action. So Nature provides, as it were, a Cerberus to guard the portals of the alimentary tract or rather indeed to fortify its whole course, just as in her beneficence she has conferred germicidal properties upon the blood, certain fluids and the cellular elements, or their constituents, of certain organs.

If then the normal intestinal and gastric juices possess such desirable and valuable attributes may we not conclude that the vast majority of cases of infectious disease of such tract are direct results of a vitiation of or deficiency in the quality of each secretion? If such be the case then scientific therapeusis demands the destruction and elimination of infectious material by the institution of normal processes elaborating normal secretions as well as, if not more than, the direct antagonism of antiseptics themselves. Antiseptics may be of decided value however when they have the power of ridding depressed vitalities of the incubus of germ life.

While large numbers and varieties of micro-organisms do exist normally in the digestive tract they are ordinarily incapable of injurious action because they are rendered inert by the normal digestive fluids. But the moment, however, that such normal secretions, become perverted, vitiated or arrested the germs already there, or those introduced with the ingesta, are placed under

conditions favorable to their development and as a consequence fermentative changes ensue. Once instituted who can foresee the result? Will it be simply a case of primary and local infection or will it result in a more complex and dangerous secondary and systemic infection? This depends entirely upon the nature of the germ or germs and also the facilities present which are favorable or unfavorable to successful and undisturbed development. When only a single local infection supervenes it may be and is possible by the use of proper antiseptic measures and the administration of proper antiseptic remedies in sufficient quantities to limit or arrest the morbid condition. Not always by destroying the organisms themselves, but by instituting a train of conditions unfavorable to their subsequent growth and development. This must, however, remain little else than palliative and temporary in effect so long as the secretions of the digestive tract are at fault and allowed to remain so. Furthermore we can anticipate little else than unsatisfactory results as long as we expect a small amount of antiseptic, such as is hardly more than sufficient to sterilize a superficial ulceration, to promptly, thoroughly and sufficiently disinfect the whole intestinal tract with its many square feet of mucous membrane, to say nothing of the accumulated infected secretions and excretions. Catharsis, elimination and irrigation must precede and mechanically prepare and make clean the way for the antiseptic which is to follow—that is, a minimum amount of work should be left for it.

IX.—Their Value and Use in Surgery.

The primary elucidation of the principles of antisepsis originated with the surgical branch of the healing art and it is but natural that we should look to this department of medical science for subsequent development and improvement. Have our expectations been realized or has Time, with ruthless hand, swept all record from the history of progress? Nearly three decades ago the principles of antisepsis first came into practical use in surgery and the subsequent history of those principles, from the very first period of their inception, has been one of continual and uninterrupted progress. Within the past few years the results of bacteriological research have completely revolutionized surgical pathology and surgical methods. A large majority, if not all, of the acute and chronic inflammatory processes and lesions, as well as wound complications, which are brought to the attention of the surgeon are due to micro organisms. For this reason it is necessary and expedient that the importance of bacteriology as an integral portion of the science and art of modern surgery be given due and proper recognition. These recent advances in surgical pathology, involving surgical methods as they did, laid the very foundation for those brilliant achievements of modern surgery which read like the pages of a medieval romance. The debt which modern surgery owes to bacteriology and bacteriological research is peculiarly great, for to it must be accredited a large measure of

the success attendant upon its later years. The knowledge which has been derived from the systematic investigation of disease, impelled by the aid afforded by bacteriology, has opened new fields of usefulness and materially extended the sphere as well as increased the utility of the surgeon himself. Indeed to such good effect that many conditions formerly and vainly treated by medication are now speedily and successfully obviated by the art of the surgeon.

In the olden days operations were performed, it is true, upon the various cavities, cranial, thoracic and abdominal; but such cases, for reasons which are now obvious, were so speedily and uniformly terminated by death from septic causes that intrepid indeed must be the heart and hand which dared stand undaunted in the very face of assured disaster. The values of antisepsis and asepsis were less than vaguely known and appreciated and though such conditions were at times somewhat imperfectly obtained this was rather the result of chance than design. The bravery and no less the success of a McDowell under these conditions, with a howling mob on one side and a fearful operation with a still more fearful outlook as to mortality on the other, was little else than marvelous and phenomenal. This exceedingly hazardous chance of success has been entirely obviated by modern methods; the *sanctum* of the human body is now devoid of any *sanctum sanctorum* within which it is forbidden the invading hand of the surgeon to enter— the very centers of life and function are approached with little or no fear of untoward consequences.

This confidence is not the child of audacity but the offspring of confidence and success. Abdominal surgery has sprung into bud and blossom beneath the kindly influence of modern aseptic and antiseptic methods. The thoracic cavity is invaded and no ill result is anticipated. Cranial surgery is now a sturdy youngster though only of some seven or eight summers. Cerebral localization is the logical outcome of modern methods of research and the spirit instituted has stimulated cerebral surgery to renewed strength. All of these triumphs were possible only upon one contingency—complete and thorough antisepsis, which of course includes asepsis.

But the greatest achievement of modern surgery is not so much in the triumphs of either abdominal or cerebral surgery; nor indeed of any one or more particular classes of operations. This lies in the *method* which has brought every organ within the domain and under the influence of the surgeon—it forms the very foundation upon which the superstructure rests. The victory and success of that method manifests itself no less in recovery from the simplest operation than in that from laparotomy or craniotomy or the extirpation of a cerebral tumor without the formation of pus or the development of pyrexia. So great is the importance of this method that the introduction of antisepsis marks the dawn of modern surgery. The value of the service which Lister had rendered mankind was exemplified when Queen Victoria conferred knighthood upon him. This was honor, this was glory—but the unfading and imperishable glory of Sir Joseph Lister's life is to have

ushered in an era which has snatched life from death in that it has so markedly reduced the mortality of mankind in so far as death by unnatural septic means is concerned. He recognized and appreciated the fact that wound infection is dependent upon the presence and influence of micro organisms. But he did much more than this, for he adopted measures of treatment based upon this truth; he not only recognized the evil and appreciated its source but also formulated a systematic method of combating these microscopic yet omnipotent as well as omnipresent foes of the surgeon. His fame will rest safely and securely upon the establishment of these fundamental *principles* even if every detail of his original method be supplanted by better ones. Indeed this has taken place to some extent already and will probably continue to do so. The original spray and dressing Lister has now discarded himself, explaining that these were but the essential crudities which occur in the development and perfection of any system. But the *principles* upon which they were founded remain absolutely unaltered and unshaken in every particular; for of a truth, the elapse of time and the accumulation of experience all bear testimony to, as well as strengthen, their unassailable position. The antiseptic and aseptic methods depend no less upon the researches of bacteriology than upon clinical experience—indeed, in the development of these methods both work together hand in hand, the one announcing principles which the other puts into practice. As Dr. Edwin Hamilton has most aptly said: "The surgery of to-day seems ele-

vated on a tripod of three solid enduring feet—they are, anesthetics, antiseptics and experimental research."

The stage of controversy as to the value of the methods of antisepsis and asepsis has long past, for, with the exception of a very limited number of individuals the surgical world is unanimous in its unqualified approval of the method which has yielded so many brilliant results. Moreover those very few who affect to dispute the efficacy of the principles make use of them by different methods. Any procedure made with a view to the exclusion of germs is metaphorically and literally an antiseptic procedure. Lawson Tait who bitterly and maliciously assails not only Lister's methods and principles but his very personality also, completely sterilizes every instrument or dressing by the *antiseptic* action of heat; his excellent results are due to a rigid and thorough application of these principles—yet he piously raises his hands to Heaven and renders thanks that he is not as other men are. As Dr. J. William White aptly says, the animus of his attack is shown when Tait naively says that Lister has completely ignored him and his results for the past twelve years. Bantock owes his results to precautions identical with those of Tait. Their mortality records are low, it is true,—4 per cent in Bantock's practice and 3.3 per cent in Tait's practice. But Thornton, a countryman of Tait, working under the same conditions and in the same field of work, has, by a judicious combination of antisepsis and asepsis, obtained the marvelously low mortality record of 1.88 per cent—a distinct and signal

gain over both Bantock and Tait, Bantock's mortality being 122 4-9 per cent greater and Tait's 83 1-3 per cent greater than that of Thornton. These results have also been attained by Price and others of our own country.

The clinical and bacteriological proof that suppuration, pyemia, septicemia, erysipelas and other similar complications are due to the presence and influence of micro-organisms is practically absolute. Lister has said: "The germ theory of putrefaction is the foundation of the whole system of antiseptic surgery, and if this theory is a fact, it is a fact of facts that the antiseptic system means the exclusion of all putrefactive organisms." This theory is founded upon a mass of correlated and substantiated facts, experimental, clinical, physiological, pathological and bacteriological in character; these are sufficient to establish it upon a firm and substantial basis. But the time for controversy is past; the *principles* are indubitably established—the only debatable ground is as to the selection of *methods* of carrying out those principles and as to the perfection of details. The constant and thorough researches of patient and trustworthy investigators have but confirmed Lister's statement in every degree. The clinical proof is equally strong. The statistics of all operations, major and minor, in the pre-Listerian period as contrasted with those of the past two decades, establish the fact that those septic diseases which were rife in private, but more especially hospital practice have almost entirely disappeared. Formerly these diseases

slew thousands and tens of thousands, but now the mortality from these causes is almost *nil* and the diseases themselves have been almost entirely banished. Formerly surgeons attempted to *produce* suppuration and to prevent primary union; modern surgery teaches us to secure primary union and to prevent the occurence of suppuration—indeed the formation of pus is looked upon as a tangible cause for reproach to the surgeon in charge. Compound fractures, which were formerly among the most dangerous of accidents, are now scarcely more so than simple ones. The rate of mortality consequent upon amputations and abdominal sections has fallen nearly to zero. Formerly recovery in such cases, especially in abdominal section, was *hoped* for and fondly hailed as an evidence of superior skill on the part of the surgeon. At the present day recovery is not simply hoped for but confidently expected as a matter of course—the operator not only deserves success but he also commands it.

The history of the development and establishment of this great theory which has so profoundly influenced the progress not only of surgery but the whole of medical science as well, is the result of the labor not of one but of hundreds of the world's choicest intellects; it constitutes one of the brightest of all the chapters in the record of human progress. It belongs to no one nation exclusively but is the common property of the civilized world, for it has been at once an evolution and a revolution in the complete consummation of which all nations have shared. In Germany and France

Schwann and Pasteur demonstrated that putrefaction is due to the presence of micro-organisms. In Scotland and England Lister applied this fact to surgery, demonstrating that the statements of Schwann and Pasteur hold true also in the case of living flesh. In the United States, Austria and Germany further applications and perfections of technique have been attained; while in the United States, France, Germany, Great Britain, Italy and Russia immense strides have been made in the direction of the development of bacteriology and surgical pathology.

But let us glance briefly at some of the benefits which the principles of antisepsis, which naturally include those of asepsis, have conferred upon humanity.

In the period of 1864 to 1866 inclusive, Lister operated in the city of Glasgow. The mortality in this series of operations of all kinds was 45.7 per cent; these deaths were largely due to *septic* complications and diseases. In the period of 1867 to 1869 inclusive he began gradually to employ his antiseptic methods and the mortality sank remarkably—to *15 per cent!* This meant that whereas pervious to the use of his antiseptic method only slightly more than one-half of his patients survived, under its use about six-sevenths survived. He began to improve the details of his system and moved to Edinburgh. During the period of 1871 to 1876 inclusive he treated five hundred and fifty-three grave surgical cases with a mortality from septic conditions reduced to—*.36 per cent!* Thus in twelve years his mortality rate dropped from 45 7 per cent to .36 per

cent; without antisepsis it was *127* times as great as with it. This diminution is so startling and so striking that when we remember that the different results were obtained by the same operator upon the same class of patients for practically the same injuries or diseases, they seem, *ipso facto*, not only conclusive but little short of the marvelous.

Somewhat later the methods of Lister and those current before the introduction were subjected to comparison. He, with antiseptic precautions, and Spence, without antiseptic precautions, worked in the same hospital upon the same class of patients for practically the same conditions. Spence lost three times as many patients as Lister. In deaths from infectious disease Lister had a mortality record of .33 per cent, while that of Spence was 2.4 per cent, *or nearly eight times as great as that of Lister!*

But these results were not peculiar to the practice of Lister, the originator of the system; they were corroborated and confirmed by every impartial observer and operator. Nussbaum has distinctly and expressly stated that in the forty years experience in his clinic, under himself as well as his predecessors, deaths from wound diseases and wound complications were so common, prior to the introduction of antiseptic methods, that even those patients with the slightest injuries frequently succumbed to them. He furthermore stated that during this same period erysipelas and abscesses were matters of daily occurrence, that 80 per cent of all wounds and sores were attacked by hospital grangrene and that

nearly all cases of compound fracture terminated in death. But immediately upon the introduction of the antiseptic method all of these diseases suddenly disappeared and healing by first intention, *previously almost unheard of in his serviee*, became the rule instead of the exception. His statistics also show that while for sixteen years previously hospital gangrene, erysipelas, pyemia and septicemia had *never* been absent from the wards of the Munich General Hospital they suddenly vanished upon the introduction of antiseptic methods of wound treatment.

Volkmann states that in his practice the mortality in compound fractures was above 40 per cent. Immediately before he adopted antiseptic methods he had twelve cases of compound fracture, every one of which was terminated by death from septicemia or pyemia. He had become so discouraged by the alarming mortality from septic causes, the prevalence of gangrene, erysipelas, pyemia, septicemia, etc., that he declared his intention of closing his hospital. As a *dernier ressort* he tried the methods of Lister. From that time until the year 1881 he had in all 135 cases of compound fracture *with not a single death from septic causes!*—133 out of the 135 completely recovered; of the remaining two, one (a drunkard) died of *delirium tremens*, the other of fatty embolism of the lungs within two hours—before treatment had been fairly instituted. This means that only one death was directly due to compound fracture and even then by an unfortunate accident which can hardly be averted. In his practice previously, with a mortali-

ty of more than 40 per cent, he would have lost 58 patients. This means that in his experience with antisepsis in compound fractures up to the year 1881 he had saved 57 lives which would have otherwise been needlessly sacrificed. Contrast the mortalities—more than 40 per cent on the one hand, .74 per cent, three-quarters of one per cent, on the other. That is, this mortality without antisepsis was nearly fifty-eight (58) times as great as his mortality with it. What a parallel! The figures speak more forcibly than words. It is needless to say that Volkmann did not close his hospital, far from it—he became one of the sincerest admirers of Lister and one of the staunchest advocates of his system.

Monsieur le Docteur Briquot shows in his statistics that the mortality in the French hospitals after major operations had been 52.5 per cent before the introduction of antiseptic methods, but that the introduction of antisepsis lowered the death rate below 11 per cent. In the Pennsylvania Hospital there were 116 cases of compound fracture treated in the period 1839 to 1851. In these, excluding those requiring amputation, there were 51 deaths—a mortality of 44 per cent. In the New York Hospital, during the same period, there were 126 cases treated; in these, excluding amputations, there were 68 deaths—a mortality of 48.4 per cent. In the surgical clinics of Vienna and Zurich, during the period 1860 to 1876 and prior to the use of antisepsis here, there were reported by Billroth 180 cases of compound fracture with a mortality, excluding amputation, of 41 per cent. In the Obuchow Hospital of St. Petersburg, 106

cases gave a mortality of 68 per cent. In Guy's Hospital, London, there were, during the period 1841 to 1861, 208 cases with 50 deaths—a mortality of 24 per cent. It is but justice to whom justice is due to say that I have obtained many of the statistics above quoted, from a masterly and scholarly article upon antisepsis by no less an authority than the well-known surgeon of Philadelphia, Dr. J. William White. An analysis of the 736 cases would give us an average mortality of 45 per cent *before* the use of antiseptic principles and methods; this corresponds with the statement of Volkmann that in his practice the mortality in compound fracture was more than 40 per cent. Upon the introduction of antiseptic methods it fell immediately to 4 per cent. That is, whereas in the 736 cases quoted more than 331 were terminated by death, such results under antiseptic precautions would only occur in about 30 out of the whole number of 736 cases. At the present day, with the improvements in methods, the mortality is still lower; now death is far more rare than it was formerly common. Dennis recently reported 516 cases of compound fracture in which there was absolutely no death from septic causes.

Dr. Thomas G. Morton in one of his Pennsylvania Hospital reports writes as follows:

"From the spring of 1875 to the same period in 1879, a period of four years, there were performed 108 amputations upon 100 patients. Of this number 17 died. Five of these deaths took place within the first thirty-six hours following the admission of the patient, and in

each instance from recurring or continuous shock. * * * We are greatly pleased to be able to report that during the past five years there has not occurred in the surgical experience of the hospital a single case of pyemia. * * * We believe that this result is due to the very perfect system of forced ventilation by the fan, the scrupulous cleanliness of the wards, and the free use of carbolic acid in our dressings."

It is of passing interest to note that by the year 1886, nearly eight years ago, the value of antiseptic measures had even forced its attention upon crowned heads, for in that year the King of Servia issued the following proclamation:

"Whereas it is irrefutably proved by science that the so-called antiseptic trsatment of wounds yields more beneficial results than all other methods, we are pleased to order that henceforward the said antiseptic plan of treatment be solely employed in all the hospitals of our kingdom, and that corrosive sublimate and iodoform be used until our further disposition."

Dr. J. Knowsley Thornton, the President of the Medical Society of London, in addressing that body, said: "I am not ashamed still to use the spray and all the precautions which have advanced my results in ovariotomy to 1.88 per cent mortality (as against Bantock's 4 per cent and Tait's 3.3 per cent) and I find increased practice and a steady adherence to methods which have yielded me good results in the past, increase in like ratio my success in all abdominal operations. Every operator of prominence improved his results enormously as soon as

he adopted Listerism; then having learnt how to be surgically clean, he has found for himself ways of attaining this end with more or less success by methods differing from those of Lister. The sum and substance of it all is, that if we had never had Lister to teach us true cleanliness, we should never have used antiseptics, flushings or drainage tubes to attain it. The great advance is due to the antiseptic system, the minor details are merely the different ways of attaining the same end—asepticity. Time alone will show what is worth retaining and what we may safely cast aside."

At least ninety per cent of the surgeons of the present day recognize the value of the modern methods of operative and wound treatment. When we consider the formidable array of statistics, the conclusions drawn therefrom and the lessons which they teach, it seems established beyond all cavil, question or doubt that thousands of lives have been saved every year by judicious application of the principles of Lister that would have been sacrificed by an application of those methods which were in vogue prior to the introduction of antiseptic surgery. If such an abundant measure of success has attended the treatment of accidental and infected wounds, how much greater should it be in operative work; here the wounds are inflicted by the surgeon himself and under conditions which afford an opportunity of cleansing away most of the infectious material from the site of the operation. Thus the surgeon is enabled, as Fowler aptly says, "to apply the ounce of prevention rather than be compelled, as in accidental wounds, to use the pound of cure."

It is now clearly the legal as well as moral duty of every individual who attempts the practice of surgery to prevent the access of germs to the wounds of his patient by every means within his power. It is not a mere matter of choice, it is incumbent upon him, it is obligatory or else he must expect to bear the stigma of merited reproach. By proper care in the exercise of absolute surgical and bacteriological cleanliness this can be secured. As Gerster has said in his "Aseptic and Antiseptic Surgery."

"The fear of suppuration with its dreadful consequences does not stay now the hand of the surgeon as of old, when an operation was always considered a forlorn hope and a last resort. Strangulated herniæ, for instance, are not allowed to gangrene as often as formerly, and herniotomy is readily resorted to, as it is well known that the dangers of an aseptic herniotomy done on a healthy gut are diminutive in comparison to the certain and enormous danger of strangulation itself.

By the conviction that a fault of omission may be followed by irremediable mischief, the sense of responsibility is stirred up to vigilance, which again breeds self-reliance and firmness of purpose in advising and carrying out incisive measures, made clearly necessary by a well-recognized danger to life or limb. And an additional degree of responsibility is imposed by the very safety of aseptic operations.

It can not now be successfully denied that *the surgeon's acts determine the fate of a fresh wound, and that*

its infection and suppuration are due to his technical faults of omission or commission.

* * * But he who becomes a master, to whom the primary healing of a fresh wound remains not a curiosity but becomes a matter of course, will not doubt the great change that has come over surgery."

If it was possible by the aseptic methods to secure a complete and absolute exclusion of the germ from the wound surface then the use of antiseptic substances would be entirely unnecessary. But this ideal condition is neither completely nor easily obtained for the operator is continually liable to forget or neglect some minor detail or precaution which renders inutile all of the care hitherto taken; we must conjoin these precautions with the proper use of heat and antiseptics if we would secure further and proper protection. It seems strange to many how slight a discrepancy or flaw or lack of precaution may disturb the entity and success of aseptic methods; indeed it is exceedingly difficult to convince the majority of physicians (even those making use of proper precautions) that the touch of the completely sterilized finger or instrument to a non-sterilized object, such as one's own body or clothing or an assistant's clothing or a door-knob or an unsterilized instrument or dressing may vitiate the entire operation and seriously endanger success by the introduction of even a few microbic germs within the wound. For we must constantly bear in mind the remarkable fecundity of these lower forms of life, how a few solitary germs may within a very short space of time become many, many millions!

We frequently hear of such discussions as "Asepsis *vs.* Antisepsis," or are greeted by the news that *aseptic* surgery is displacing *antiseptic* surgery—just as though these were two diametrically opposed systems or methods. Aseptic surgery undoubtedly marks an important advance in the attempt to perfect surgical detail, but it is none the less antiseptic surgery. Antisepsis is that condition which is opposed to sepsis or putrefaction; it makes no difference whether the condition is obtained by destruction, inhibition or exclusion of the germ—putrefaction is prevented and that is the central and essential idea of antisepsis. The object of antiseptic surgery is to secure an aseptic condition in a wound. There is no opposition between asepsis and antisepsis, one is the logical outcome of the other. Although thorough and complete asepsis is the ideal of every surgeon at the present day yet it is no less equally certain that the time has not arrived when we can afford to dispense with antiseptics. It is undoubtedly a fact that aseptic methods should be reserved for sterile or sterilized wounds and not only to sterile wounds but to those in which we have reason to anticipate little or no discharge, with the accompanying risk of subsequent infection and putrefaction of such discharges. In all other cases chemical antiseptics are necessary; in infected wounds asepsis is an impossibility. Indeed in a large proportion of those cases which come beneath the control of the surgeon we need chemical sterilization of wounds and dressings as much as we ever did. There is as yet no good reason deduced for casting aside ut-

terly the weaker chemical solutions which are in use at the present time. Undoubtedly all antiseptic solutions which are sufficiently strong as to appreciably compromise the vitality of the tissues must be discarded; but those disagreeable effects upon the hands of the operator and the tissues of the patient are usually only encountered when solutions of too great strength are used—such as 1:1,000 of mercuric chlorid or 1:20 of phenol. This objection, as White says, applies with much less force to solutions of 1:2,500 of the one and 1:40 of the other; these latter solutions experience has proven to be practically just as effective.

However, we must not forget that surgical disinfection has progressed not so much by the introduction of new and multitudinous antiseptics as by a better understanding of the modes in which they act efficiently and the conditions which impair such efficient action.

In the vast majority of cases organisms gain access to wounds by means of direct contact—that is, the germ is actually and materially conveyed to the seat of infection. Nevertheless the possibility of infection from the matter floating in the air is not to be overlooked altogether, although the chances of infection from this source are certainly slight; careful experimentation has demonstrated that ordinarily the organisms exist in this medium in so slight a degree as to hardly merit serious consideration. This may be due to the antiseptic action of light in combination with that of the atmosphere, which antiseptic properties we have mentioned in preceding papers; or it may be due to the fact

that the organic elements as well as the inorganic elements of the atmosphere may be deposited finally as dust. Certainly settled dust, especially that of hospitals, is comparatively rich in germs. In the collections beneath the nails, especially of surgeons and physicians, and in the rich soil of the epidermis, in the clotted blood and dried infectious discharges upon instruments we find an abundance of micro-organisms, pyogenic and pathogenic. Indeed in operative work their presence in the epidermis and their non removal or non-destruction is one of the commonest and most potent causes of infection; then also the contact of non-sterilized objects, whether they be the hands of the operator or of the assistants, or whether they be the instruments and surgical dressings used, furnish other palpable foci of infection. Or else absence of sterilization or imperfect sterilization favor the development of those organisms and substances which ultimately find their way into the wound itself where they encounter in abundance pabulum sufficient for their subsequent sustenance and by their presence and injurious action prejudice the natural operations of repair. It is much easier to destroy these organisms outside of the wound, or body, than in it, and in a proper appreciation of this fact lies confidence of perfect success. These conditions then demand the thorough preparation and sterilization of the surface of the patient, more especially in the vicinity of the site of the proposed operation; and not only a thorough sterilization of the epidermis itself but also of *everything*, *absolutely everything*, which is in any way likely

to come in contact with the wound area. There should be, if possible, absolutely no avenue by means of which infection can reach such area. Chemical sterilization is still important—even indispensable in some fields of modern surgery; but as concomitant and valuable factors we also have certain mechanical measures of purification which form an essential part of aseptic preparation properly so-called. No one link in the chain is to be overlooked. Demosthenes once said that there were three requisites for perfect oratory, namely, action, *action* and ACTION. So also there are three essentials in perfect antisepsis, namely, thoroughness, *thoroughness* and THOROUGHNESS. The thickened epidermis about the wound edge is a favorite nidus for germs; they collect, and warmth and moisture aid in their subsequent development. Not only must the germ be thoroughly killed or excluded but the possibility or subsequent infection must also be forseen and guarded against. For instance, in even an ideal aseptic and antiseptic operation in which there is much subsequent discharge or oozing there is danger of infection and subsequent decomposition of these discharges; they must, if possible, be absorbed and sterilized and for this purpose dry dressings are frequently valuable. As Gerster says: "The dryer the operation the dryer the course of healing" and also that "dry absorbent dressings, favoring rapid evaporation, are most useful in the treatment of extensive aseptic wounds." Indeed in an extensive correspondence with the leading surgeons of America, Great Britain, France and Germany I find the dry dress-

ing almost universally endorsed; the moist dressing being used in infected areas and the dry dressing being almost exclusively used in aseptic operative procedures.

Experiments upon animals, as we have previously shown, have demonstrated the fact that when micro-organisms were introduced into the circulation and any portion of the body was injured, that is where there was a local depression of vitality, that there developed a subsequent invasion of such injured tissues by the micro-organisms—that is, there was a sort of internal invasion. The virulence of such germs, or their capacity for virulent action, was modified in certain degrees according to the length of time they remained in the circulation; their number and vitality being evidently lessened the longer they remained in contact with the blood—that is, within certain definite limits. For instance, this power of the blood is definite and limited and in the case of invasion by large numbers of germs would be exhausted before securing complete destruction of all the germs. In this latter case, when the blood has lost its germicidal power it becomes a good culture medium and the germ then thrives rather than dies. Yet if limited numbers of these self-same micro-organisms be injected into perfectly healthy non-injured animals not only is such injection followed by negative results but the destruction of the germs is prompt. This demonstrates then that certain tissues have a certain amount of inherent germicidal power within certain limits; also that the healthy organism is frequently able to cope, unaided, with disease. But when the

health and the properties resultant thereon are disturbed or when the germ invades in large and overwhelming numbers it then becomes necessary to afford such aid as will reinforce these antagonistic properties which are peculiar to health. It is incumbent upon us to *prevent* infection, as far as is possible; this means that we should so protect the parts from contact with micro-organisms that their entrance within the systemic portals, or even their lingering at the gates as it were, would be an utter impossibility. If they once succeed in reaching the tissues, though every effort be made to destroy them lodged, as they are, in the vital strongholds, it is possible that though partly devitalized they may ultimately renew their life with as much vigor and be fully as capable of harm as before. In order to overcome this possibility we must prevent their access —indeed, as Gerster says: "Prevention has become the watchword of modern practice, and it can be said that, by the successful employment of the preventive methods of the present day, surgery has become a *conservative* branch of the healing art." After the germ has once gained entrance, and a foothold, not only may it be difficult either to dislodge it or kill it but in our zealous efforts in the latter direction we may even seriously impair the vital activity of the cellular constituents of the adjacent tissues, producing almost as much harm as the germ itself. The acme of success lies in preventing development—not in allowing it and then cutting it short subsequently, but in rendering it an utter impossibility. The acme of success lies in prevention.

In closing this brief and somewhat imperfect *resume* of the triumphs of antisepsis in the surgical art we can not refrain from quoting that magnificent apostrophe which Arpad Gerster has so eloquently uttered:

"Having passed in review the present status of anti-parasitic surgery, we see that although incisive changes have befallen the means employed, the principles upon which the discipline was grounded remain unshaken. The living spark of truth has survived the pedantry and over-zeal of the advocates, as well as the sneers and contempt of the opponents of the new departure. Its blessings have soothed and removed untold suffering and misery—have saved I might say, millions of lives. For all this humanity is indebted to one man, whose intellect pierced the deadly mists that overhung the practice of surgery. That to the activity of the surgeon, though it still remains surrounded by grave responsibilities, was added a vastly increased element of pleasure, the *gaudium certaminis* against disease and death—for this gift to his fellow-surgeons we are indebted to Sir Joseph Lister."

X.—Their Value and Use in Obstetrics and Gynecology.

The influence of antisepsis and asepsis was far-reaching. It pervaded wholly all of the various fields of medical science; it not only revolutionized surgery and left its decided impress upon the general practice of medicine but also very notably affected obstetrics and gynecology. No sooner had the benefits of Lister's teachings been fully demonstrated than obstetricians and gynecologists began the application of similar methods and principles in the lying-in chamber and operating room. This was done anxiously and expectantly at first but the ultimate fruit of success was the establishment of supreme confidence. In obstetrics, as well as in the other fields of the medical art, sepsis is the chief general condition dependent upon the presence of micro-organisms. The technical use of this term implies not only the actual presence of such micro organisms but also the various accompanying forms of intoxication which result from certain forms of necrobiosis or destruction of the minuter and cellular elements of the tissues. It is not necessary to uphold this statement by lengthy argument, for it has been indubitably proven—indeed the occurrence of sepsis and septic conditions is now universally admitted to be due to the presence of certain and particular forms of germ life. Of the conservative and other various phenomena induced by their presence, suppuration is at once the most

common and most obvious. The commonest of the pyogenic or pus-forming germs are the *Staphylococcus pyogenes aureus*, *albus* and *citrus* and the *Streptococcus pyogenes*.

These germs by their presence induce septic conditions, *ergo*, prevent their access to and subsequent invasion of the tissues and the occurrence, development and consequences of sepsis, in its various forms, are also prevented. This also is universally acknowledged. However much we may disagree in our opinions as to the use or virtue of any particular antiseptic *substance* we must and do all agree unanimously as to the extreme virtue of the *principle*. There is not the slightest doubt but that it is infinitely better for the parturient woman not only to render such patient absolutely clean, domestically, surgically and bacteriologically, but also to exclude all septic influences from the puerperal chamber. Of course ideal conditions in this respect are hardly possible to attain and it is infinitely easier to write this than to do this; but it is possible to attain a relative freedom from such infectious influences by the exercise of absolute care and patience—"patience is bitter but its fruit is sweet." It may cost the physician some inconvenience and trouble, but is the life and health of the patient to be bartered for the convenience of the professional attendant?

The means by which disinfection is accomplished are legion. Probably the best means of sterilization of instruments and dressings is by the use of the antiseptic and germicidal power of moist heat; this is readily at-

tained by the use of the Arnold and other forms of sterilizers which are now made for the use of the physician and surgeon. Sterilization of instruments and dressings materially decreases the chances of infection as far as the armamentarium *per se* is concerned. But we must also be mindful of the fact that there are other avenues by means of which infection may gain access and these are of equal, if not greater, importance—namely, the patient's own body and the operator's hands, as has been shown in a previous paper. Kelly, Robb and Ghriskey, of the Johns Hopkins University, have proven by rigid and ample experimentation that the *Staphylococcus pyogenes albus*, and sometimes *aureus*, are present in enormous numbers on the hands and about the nails of all physicians and surgeons. This is but natural when we consider how often they come in contact with infectious material. The possibility of direct transmission of infection by the hands of the physician first seemed to suggest itself in the occurrence of puerperal septicemia under conditions which seemed to indicate such a cause. Of this fact there are recorded many lamentable instances. This origin of the disease was pointed out by Gordon toward the latter part of the last century; he said that he himself "was the means of carrying the infection to a great number of women" and also traced the spread of the disease in the same way in the practice of certain midwives. As Playfair remarks, in some remarkable instances this unhappy property of carrying contagion has clung to individuals in a way that formerly seemed

most mysterious and led to the supposition that the whole system had become saturated, as it were, with some subtle and volatile poison. One of the strangest cases of this kind was that of Dr. Rutter, of Philadelphia, which caused much discussion. He had forty-five cases of puerperal septicemia in his own practice in one year, while none of his neighbors' patients were attacked. It is related that, in order to "rid himself of the mysterious influence which seemed to attend upon his practice, he left the city for ten days, and before waiting on the next parturient case had his hair shaved off and put on a wig, took a hot bath, and changed every particle of his apparel, taking nothing with him that he had worn or carried to his knowledge on any former occasion; and mark the result. The lady, notwithstanding that she had an easy parturition, was seized the next day with childbed fever, and died on the eleventh day after the birth of the child. Two years later he made another attempt at self-purification, and the next case attended fell a victim to the same disease." Meigs, in commenting on the case, refused to believe that Dr. Rutter carried the poison, but rather thought that he was "merely unhappy in meeting with such accidents through *God's* providence," and asks, "Did he distil a subtle essence which he carried with him?" It appears, however, that Dr. Rutter was the subject of a form of ozena which was sufficiently severe to disfigure him in time, from its effect upon the contour of his nose, as Harris says. It is, of course, obvious that under these peculiar circumstances his hands

could never have been free from pyogenic organisms and septic matter. This is of peculiar interest because it shows how obscure may be the source of infection and how thorough must be the preparation which would obviate its transmission to a patient. This is only one of many, many thousands of similar cases—that is, similar in the fact that the infection was directly transmitted.

Not only may contagion dwell within or upon the person of the physician, as in the case just cited, but Kelly, Robb, Ghriskey and others have proven that pyogenic organisms are to be found in quantity upon the hands and beneath the nails of every physician and surgeon—at least, this occurred in the case of every single one of a large number who were examined. Not only were these germs found in quantity but it was also demonstrated that washing and scrubbing the hands with brush, soap and water, even as long as twenty-five minutes, was utterly inadequate to remove all of the germs. Nevertheless such washing and scrubbing by mechanically removing detachable epithelial and subungual debris which are constantly loaded with germs materially reduces the chances of infection. In sixty-five experiments upon physicians who scrubbed the hands freely, from ten to twenty five minutes, with strong brown soap and hot water frequently changed, fifty-six (that is, all but nine) yielded numerous colonies of pyogenic organisms; in almost every case these germs were specimens of *Staphylococcus pyogenes albus* and in some cases *Staphylococcus pyogenes aureus*. The remain-

ing nine owed their escape to the inhibitory influence of mercuric chlorid which had been used as far back as the previous day. In seven additional experiments which were made upon nurses, positive results were obtained in every case, developing variously forty, sixty, six hundred and myriads of colonies of *Staphylococcus pyogenes albus* and a few of *aureus*. As the experimenters remark, it was known in each instance that the test was about to be made and all endeavored by unusually vigorous efforts to earn the credit of "no growth."

Kelly further remarks that solutions of corrosive sublimate (mercuric chlorid or bi chlorid of mercury) even as strong as 1:500 are *not* germicidal after immersion of the hands from two to five minutes. The mercury salt acts either by mechanically coating some portion of the coccus or else chemically combining with it, *thus only inhibiting further growth until the salt is precipitated or otherwise removed.* Kelley says: "This I have repeatedly shown to be true following both the ordinary practice of immersion of the hands from two to five minutes in 1:500 and 1:1000 solutions after a preliminary washing for ten minutes with soap and water, and again after carefully following out Fuerbringer's method, now so generally adopted. The latter method was distinctly shown to be inefficient in almost every instance. It is briefly the following:

Clean the nails with a pointed steel.

Scrub the hands, especially the nails, one minute with soap and hot water and a sterile brush.

Immerse the hands in alcohol (not under eight per

cent) for one minute; immediately transfer hands, still wet with the alcohol, to a freshly-prepared solution of mercury bi-chloride, 1:500, for one minute, *when they are supposed to be sterile.*

I exhibit in my hands four tubes carrying cultures which failed to develop after sterilizing by this method, illusively showing an apparent sterility, for here on the other hand, are cultures taken from the same fingers *after precipitating the bichloride with a sterile ammonium sulphide solution, and these show innumerable colonies.*"

These results are striking and are but confirmed by the late experiments exploding the old classic belief in the inordinate germicidal power of mercuric chlorid, which has been heretofore placed so inexactly and so inaccurately high. He further says: "It is a remarkable fact, of great practical importance, that this inhibitory effect of the bichloride holds over on the hands for twenty four hours. In two instances of men who had been away from the hospital for from four to six weeks, the ammonium sulphide produced the characteristic dark stain on the fingers, showing the presence of bichloride. Here is the source of error explaining the nine negative results in the hands of my staff after simple soap-and-water cleansing. We did not then know of this property of the sublimate.

Four experiments were made also with a four per cent solution of lysol; all yielded colonies.

Three experiments with peroxide of hydrogen also furnished abundant colonies." From this we infer then that really positive results were obtained not only in

the case of the experiments upon the hands of nurses but also in the sixty-five experiments upon the hands of physicians; the nine apparent negative results being due to extraneous inhibition and not due to the scrubbing. We also conclude that mercuric chlorid, lysol (four per cent) and peroxide of hydrogen are useless as far as absolutely sterilizing the hands is concerned; the first, however, has strong inhibitory properties. Kelly favors the use of trimming and cleaning the nails, scrubbing the hands thoroughly with brown soap and hot water and subsequent immersion in a saturated solution of potassic permanganate followed by neutralization and decolorization by immersion in a saturated solution of oxalic acid; he claims that this thoroughly sterilizes the hands. Certainly such procedures are upheld by a large number of experiments in which no colonies developed subsequent to their use, even immediately after the demonstration of countless colonies after the use of soap and water. Also in the very low percentage of cases in which germs developed, in this latter case the occurrence of colonies being small and such as found consisting of small and definite numbers of micro organisms. Potassic permanganate and oxalic acid are not only harmless to the hands but afford the most efficient germicidal method of sterilizing the hands—indeed, Kelly goes so far as to say that soap and water and potassic permanganate and oxalic acid are the only true germicides for such use and therefore the best we have to-day. He further says that mercuric chlorid, although dangerous on wounds on account of its property

of coagulating and causing necrosis of albuminous tissues, has valuable properties of inhibiting, *not destroying*, those germs with which it comes in contact.

The physician must not only free himself from infection but the patient and her attendants, as well as her surroundings, must also be kept absolutely clean. The physician should exercise due care and discretion in making vaginal examinations and after delivery should pay immediate attention to lesions of the genital tract. Antiseptic and aseptic precautions have so materially lowered the death rate from child-birth that it becomes incumbent upon every obstetrician to make use of those means and every precaution which guarantee increased safety, at least. The elementary principles involved in the practice of modern midwifery may be tersely, though not comprehensively summed up as follows:

1. The patient must be made absolutely clean in all of her surroundings. The room, as well as the bed itself, must be clean and free from infectious principles —that is, as far as is practicable. Cleanliness must be insisted upon; it is not expensive—fresh air and clean water cost but little.

2. The accoucheur must render himself as aseptic as possible; also all instruments or dressings which are to be used. The instruments and dressings may be sterilized by moist heat; the hands by the liberal use of the brush, soap and water, the use of the nail brush and the subsequent use of some germicidal solution—preferably that of potassic permanganate and oxalic acid as has been previously described. The physician must make no examination until he is absolutely certain that he

can convey no infection to his patient thereby; indeed, he must avoid all examinations which are not absolutely necessary.

3. The child must receive immediate attention when born, so that there may be no danger of sepsis—opthalmic or otherwise. This precaution will not only entirely avert the occurrence of opthalmia neonatorum but of other infantile affections dependent upon the early occurrence of sepsis.

A strict adherence to the dictates of such a policy, while not entirely eliminating death from obstetric practice will certainly materially decrease it. It may be argued that many cases thrive and progress to a favorable termination without the adoption of any preventive measures whatever. This will readily be granted; but it cannot be denied that many more cases progress thus favorably under such precautions than without them. It is then the duty of the physician to spare himself no necessary precaution for the ultimate safety of the patient whose life and health is intrusted to his keeping and when he accepts the issue he also accepts this responsibility.

The benefits of antiseptic treatment in the various hospitals and lying in institutions have been so signal, so apparent, so enormous, that all criticism has been disarmed and silenced and every doubt as to value and expediency has vanished. This is happily true of hospitals, but a condition of things obtains in private practice which is not altogether to the credit of those who neglect proper precautions. Nearly twenty years ago the mortality in the various lying-in institutions

was so great that the International Congress of Physicians and Surgeons, then in session at Brussels, adopted resolutions asking for the abolition of such. The prevalence of puerperal septicemia in hospitals or institutions in which lying-in women are congregated had been constantly observed, both at home and abroad; this was accompanied in a vast majority of cases by a most appalling death rate. The disease when once developed spread rapidly from one patient to another until infection was general in spite of all that could be done. In the years 1760, 1768 and 1770 the disease prevailed to such an extent in London that in some of the institutions nearly all of the patients died. It is stated of the Edinburgh Infirmary, in this connection, that in the year 1773 "almost every woman as soon as she was delivered, or perhaps about twenty-four hours after, was seized with it, *and all of them died*, though every method was used to cure the disorder." The lying-in institutions of the Continent were conducted upon a much larger scale but the death rate was equally large here, even in some of the very best of such institutions. In the *Maison d'Accouchements* of Paris, during many different years, the death rate rose so high that one out of every three patients delivered died—on other occasions as many as ten out of fifteen women delivered died. These frightful results were not peculiar to any one institution nor to any one class of institutions—all seemed beneath the ban. In Vienna in 1823, 19 per cent of the cases died; in 1842, 16 per cent. This condition of affairs progressed until in Berlin in the year 1862 hardly a single patient escaped death and the hos-

pital was therefore eventually closed. It was upon a basis of such fact that the action of the Brussels Congress was predicated. Now the conditions are entirely reversed, the mortality in private practice being greater than that of the hospitals, although by no means alarming. The reason for this is obvious. In the hospital or lying-in institution every precaution is taken; not only are all instruments and dressings sterilized, as well as the hands of the operator, but the whole institution and its wards have been kept in as good a condition of asepsis as is possible under the circumstances. The nurses are properly trained and instructed and a systematic and thorough preparation has been made for an earnest extermination of danger from septic causes. In the home of the patient all of these conditions, even frequently with the exercise of proper care, do not always obtain. The channels by which infection is subtly transmitted or brought within the portals are many and except in illness (and not always then) no systematic effort is made to exclude it. To reproduce the results attained in the hospital or to reproduce the conditions which surround the patient in the hospital we must practically reproduce the hospital itself—or at least its discipline.

At the present day, as we have said, the mortality of private practice is greater than that of hospital practice. It is now between eleven and twelve years since antiseptic methods of treatment were introduced in the New York Maternity Hospital and the result there, as elsewhere, has been a uniform and enormous decrease in not only the occurrence of disease from septic causes

but in a most significant reduction of the mortality. Garrigues says that during the nine years preceding the introduction of such methods, (1875 to 1883), 3,504 women were confined in the institution, 146 of whom died—that is, 4.17 per cent. During the last six months before the change was made, 237 women were delivered, 19 of whom died—that is, 8 per cent. Of these nineteen, seventeen succumbed to sepsis—that is 7.17 per cent. During the last month before the introduction of antiseptic methods the total mortality reached 20 per cent and that from sepsis or infection 15.69 per cent. The results following the use of antisepsis he tabulates as follows:

YEAR.	DELIVERIES	DEATHS.		PER CENT.	
		TOTAL.	FROM SEPSIS	TOTAL MORTALITY.	FROM SEPSIS.
1884	522	8	4	1.53	0.76
1885	537	3	0	0.56	0.00
1886	446	5	1	1.12	0.22
1887	389	5	1	1 30	0 26
1888	377	3	0	0.79	0.00
1889	314	1	0	0 32	0 00
1890	345	4	1	1 13	0 29
1891	240	1	0	0 42	0.00
	3170	30	7	0.90	0 19

These figures are significant; they reveal the fact that during the years 1885, 1888, 1889 and 1891 there were absolutely no deaths from sepsis in this institution, and at no time in the years tabulated did the mortality from sepsis run above .76 per cent and in one-half of the time was .00 per cent! The mortality in the nine years preceding the introduction of antiseptic methods was nearly 500 per cent (5 times) greater than the same during the eight years following the introduction of such methods of treatment. The deaths from septic infection were reduced to one fifth of one per cent! Contrast this condition with that of pre-Listerian days. In the last six months of the non-antiseptic method in the New York Maternity Hospital the mortality from septic causes was 7.17 per cent or more than 35 out of 500; this was reduced by antisepsis to less than 1 out of 500. These mortalities give startling comparisons but the results from antiseptic methods are substantiated by Garrigues by the following statistics:

The Sloane Maternity Hospital of New York was founded comparatively recently; in the report of the first thousand cases only six deaths were reported—only one of these from sepsis. This would give a general mortality of six-tenths of one per cent (0.6 per cent) and a mortality from septic causes of one-tenth of one per cent (0.1 per cent).

Pippingskoeld of Helsingfors during the period of 1884 to 1887, with an average of 650 deliveries *per annum*, had a mortality of 0.29 per cent.

Mermann of Manheim had nearly 700 cases before a

single death occurred, and that one was due to rupture of the uterus.

Carl von Braun of Vienna in 1004 consecutive cases met with only two deaths.

Obstetrics and gynecology owe a lasting debt to surgery for the benefits of improved surgical methods and the development of great skill in operative technique as well. Indeed to the specialist in surgery are now relegated many of the operative procedures of both obstetrics and gynecology. Cesarian section, ovariotomy, hysterectomy, laparotomy for tubal pregnancy and other causes, and other kindred measures are now properly surgical operations. For their successful obviation we are indebted largely to surgical progress and the application of the results to such forms of treatment. Indeed we find that the influence of modern surgery has largely modified many of the ordinary obstetrical gynecological procedures.

By far the most formidable septic condition which confronts the obstetrician is puerperal septicemia. The condition is, or was rather, unhappily too common to need a description of its incubation, symptoms and the various phenomena which attend its course. The influence which antiseptic measures have had upon its development has already been fully considered statistically. Mermann gives the following etiological factors in the production of a puerperal infection:

1. External infection, caused by pathogenic cocci. This can be prevented by subjective antisepsis.

2. Auto-infection, as understood by Semmelweiss, which may be divided into.

(*a*) Ptomaine intoxication or putrid infection caused by micro-organisms. It cannot be combated and vaginal injections are useless. Prevention is tbe necessity.

(*b*) Patbological germs which have been lying dormant and are brought into action by the birtb. These we find in cases of old exudations, pyo-salpingitis and old abscesses of the glands of Bartholini. In these cases vaginal injections are also usually useless.

3. Vaginal infection caused by patbogenic germs wbich have found their way into the vagina before labor began.

In all of tbe branches of modern medicine tbe watcbword is prevention. Tbis is probably the only metbod by wbicb tbe development of all varieties of puerperal infection may be prevented. A perfectly ideal management of all puerperal cases may not be *theoretically* attained, altbougb *practically* sufficient to prevent tbe development of dangerous or even other tban the mildest symptoms. In very many lying-in institutions very rigid rules are laid down witb a view to the prevention of the possibility of transmission of infectious material to the patient either on the bands of tbe attendants or on instruments, napkins, etc., and tbese have met with most satisfactory results. Until recently a few practitioners ridiculed the use of such precautions wbicb were certainly strongly indicative of a proper recognition of the danger and also an earnest endeavor to remove it. Local antisepsis bas accomplisbed most valuable and fruitful results wbich are by no means to be underestimated. Many experiments and attempts bave been

made to apply a system of antiseptic medication by the internal use of antiseptic substances but these have, as yet, been unfruitful. While local antisepsis has yielded brilliant results, the outlook in puerperal infection, as far as the virtues expected from internal administration of antiseptics are concerned, is certainly, as yet, not very bright.

XI.—The Essentials of Antisepsis and Asepsis.

Thanks to the certain and infallible foundation afforded modern surgery by the antiseptic method of wound treatment and to the subsequent uniform adhesion and healing of wounds when so treated, the technique of operative surgery has received a most extraordinary and tremendous stimulus during the past quarter of a century. This was but natural for antisepsis and asepsis put within the hand of the surgeon a never-failing aid and reared up for him an ever-reliable foundation of confidence; and upon this positive foundation it was the function of modern surgery to rear a superstructure of brilliant work and of still more brilliant and indeed unparalleled results. With thorough and conscientious precautions, there is not at the present time any portion of the human body which is entirely without the pale of the dominion of the surgical sceptre—the scalpel. There is within the organism no veiled *sanctum sanctorum* to stay the hand of the surgeon in a progression which erstwhile would have been

deemed profanation. The cranial cavity and its contents no longer constitute a *noli me tangere.* The thoracic and abdominal cavities, and the joints as well, are invaded, under proper precautions, with absolutely no fear of evil consequences; they are now approached with a well-merited boldness of such a nature as would have stamped the effort in former times as the offspring of either madness or criminality. The only bugbears which can and do frighten the modern surgeon are his own personal technical sins, from which the avenging Nemesis should afford him no protection. Not only are these facts, and their proper appreciation, of the utmost value in purely reparative work but they are also of equal importance in their bearing upon diagnosis of surgical and other affections. Formerly surgery was a *dernier ressort;* it was resorted to only when all other means of relief or reparation had failed and when the chances for future failures were in consequence but increased. Now, however, we may operate not only for relief but also for information, for purposes of diagnosis, in order to lay a positive foundation upon which to build proper measures of relief, whether surgical or otherwise. Indeed it may well be said that at the present time the most radical surgery is pre eminently the most conservative in its results. These conditions necessarily and materially amplify the scope of operative skill and technique; but they also entail a double duty—thorough antisepsis, or asepsis, and thorough technique *down to the minutest details.*

Nevertheless the element of undoubted safety which

has been added to most operations has engendered some curious conditions. Clumsy and bungling operators who, under former methods, had hitherto achieved but a slight modicum of success, now accomplished even brilliant results, simply through use of antisepsis, while in other cases operators of even marvelous manual and technical dexterity signally failed, simply through lack of these proper precautions. Not that antisepsis and asepsis encouraged carelessness or that a premium was placed upon crudity—far from it! The brilliant, astonishing and classic triumphs of modern surgery were only possible by a combination of what Gerster fittingly terms "technical skill, the cunning of hand and brains, with the conscientious practice or a thorough-going cleanliness." The advantage then lay, not in the encouragement of careless work but in the fact that even in spite of it the former technical bungler was given a chance of success despite his operative bungling, while the truly skilled were vouchsafed an attainment of results which were hardly within the province of even their most sanguine expectations. Yet, on the other hand, this does not alter the fact that neglect of surgical cleanliness invites a Nemesis whose retribution is not more swift than certain in its nature. It is none the less true, as has been said, that the barbaric neglect of cleanliness and lack of attention to hemorrhage, the rough methods, the tearing and the slashing frequently necessitated by lack of anesthesia in former days has now been preceded by more exact and cleahly modes of operating. Dissection is based upon proper technical

and anatomical knowledge, hemorrhage is controlled and the operative field thus kept dry, tissues are properly retracted and the course of the knife made plain to the eye of the surgeon; clean-cut incisions are made, if possihle, which altogether materially increase or aid that natural and inherent tendency to repair. Indeed, with the ideal surgeon, his knowledge is as clean and sharp as his knife.

Not only is it positively incumbent upon the surgeon to care for his patient, hy proper surgical skill and technique, during the operation to which he has been subjected, but it is also his duty to care for the conditions which surround that equally critical period, the stage of repair and recovery. Not only must the patient he properly protected against the injury and danger of wound infection during the course of an operation but just as thoroughly, just as effectively during convalescence—the duty in this respect does not terminate until the condition and its consequences have either terminated or else the relation of physician and patient be kept no longer intact. This means the institution of a rapid, progressive and undisturhed process of repair and healing of every operative wound—not by methods which are fantastic, not by means which are impossihle, not hy methods which are not accessible to every physician and surgeon, not by an enormous expenditure of time, money and worry, but by the simple exclusion of all possible means of infection. Experience has amply taught us that every wound, with proper care and attention, may he caused to adhere and uniformly progress

to a state of consummated repair, provided that the exclusion of micro-organisms and their products from the affected tissues be secured. When we consider the protean forms in which the masked infection may assail favorable foci, it means naught else than the exercise of that eternal vigilance which is said to be the price of liberty. Unless destroyed or removed, micro-organisms cling to all objects which come in contact with the wound—this is true of even the hand of the surgeon himself. Therefore the care and foresight of the operator must not only be constant but also universal. Does this mean trouble? Does this mean expenditure of time? Yes, but it is economy of both. It does not require the one-half of either which will be required upon the occurrence of septic developments later, due to the criminal carelessness and neglect of the surgeon who has culpably exposed the life or health of the patient who has trustingly placed both in his care. More often than not when such occurs, when sepsis develops, it is frequently too late to purchase life or health by the expenditure of any amount of either time or trouble. Nor can the proper expenditure of time and trouble in the early days of the case be compared to the mortification and remorse which arises and overwhelms when it finally dawns upon the professional attendant that his selfish regard for his own comfort has been allowed to jeopardize, even sacrifice, the life of his patient. It is again but the old, old story of the stitch in time which saves nine—only in this case applied with ten-fold force. The question is now no longer a debatable one—it

stands firmly grounded upon an unassailable and unimpregnable foundation of eternal and established truth, of such strength as scientific dogma has heretofore seldom witnessed.

Slightly more than twenty five years ago Lister first demonstrated the importance of a proper consideration of atmospheric dust and the chance of consequent infection of atmospheric origin. The possibility of this he clearly demonstrated, although we know at the present time that the danger of a more material infection from instruments, dressings, hands, nails, etc., is infinitely greater. Nevertheless it is always a matter of greater safety when an operation can be performed in a clean room with smooth walls, where the possibility of stirring up dust, in any manner, from floor, walls, ceiling, furniture or ornaments has been reduced to a minimum if not entirely removed. Based upon facts which were themselves firmly founded upon ample clinical experience, and based upon Pasteur's masterly demonstration of the origin and nature of the causes of decomposition in general, Lister instituted a method, a systematic method, for the purpose of combating the operation of such causes in the living flesh of the hospital ward and sick-room. He first demonstrated that decomposition in wounds only supervenes upon contact with something introduced from without; that upon exclusion of all possible chance of infection from without no decomposition occurred. The splendid results which immediately followed an appreciation of this fact, and their substantiation by the results obtained by Volkmann,

Schede, Thiersch, Socin and others beside Lister himself, led to more extended investigations, demonstrations and enunciations upon the part of the latter. Following this came the demonstration by Lister that the causes of infection introduced from without were essentially organic in nature since they were destroyed by such measures as effected the destruction of organic matter in general. Finally he established the fact that such organic sources of infection introduced from without were capable of development and reproduction—that is, that they were endowed with life—they were living organisms.

Pasteur has demonstrated that certain germs in certain media uniformly produce certain new compounds—in this manner he not only explained butyric fermentation but even gave a minute description of the germ which was its cause. Other investigators also were at work; Billroth made researches into the nature of the specific material of wound infection. By far the most important of these investigations were made toward the latter part of the seventh decade of the present century by Robert Koch. He extended the generalizations of Lister and Pasteur, determining that in wounds or even in their absence certain varieties of decomposition were only produced, as in the case of liquids contained within glass flasks, as a result of the presence of certain organisms. And from this germ of truth developed and upon this important determination is founded the germ theory of disease—that among infectious diseases each distinct group of pathological conditions, which we

term a disease, is directly caused or promoted by the presence and action of a specific and peculiar micro organism.

After positive demonstration of this point it became self-evident that one of the most important points in the treatment of infectious diseases was the prevention or modification of the morbid processes by exclusion of all such micro-organisms, or else the institution of conditions unfavorable to their growth and proliferation. The first attempt in this direction, after the promulgation of the doctrines of antisepsis, was made by Lister himself. He attempted to prevent wound infection of atmospheric origin by the use of the spray, enveloping operator and patient within an atmosphere impregnated by vaporized solutions of carbolic acid, which was supposed to penetrate dust particles and infectious matter floating in the atmosphere and render it innocuous. It has been demonstrated, by Stimson among others, that it is not only unnecessary but that it is indeed impossible to attain the object sought, at least by such means as the spray. It is even claimed that its use is positively injurious when compared with the results given by improved methods, because it creates a more or less violent agitation of the dust particles, dragging them over the exposed wound surface in spite of the fact that the temporary and incomplete contact of such particles with the spray is utterly insufficient to destroy or arrest the development of any infectious germs associated with such dust particles. Therefore the employment of the spray if not actually dangerous is certainly useless to

say the least. It is but justice to Sir Joseph Lister to say that he has long since discarded its use himself and even condemns it now; nevertheless, although its application was faulty the principles upon which its use were predicated remain absolutely unchanged in every single essential detail. We now know that the chance of atmospheric infection is no less positive in character, though not nearly so great as formerly imagined. Tyn dall has positively and beautifully demonstrated that air becomes freed from dust by allowing the heavy particles to settle. He demonstrated that if a beam of sunlight is allowed to pass through an empty closed vessel its path is evidenced as a bright streak because of the reflection of light by the dust particles. But if the vessel is laid at rest for a time, negative results are attained, the path of light disappears because the dust particles which formerly reflected the light have sunk to the bottom and no longer float in the atmosphere of the vessel. Tyndall thus describes the experiment:

"Build a little chamber, and provide it with a door, windows and window shutters; let an aperture be made in one of the shutters through which a sunbeam can pass; close the door and shutters so that no light shall enter save through this aperture. The track of the sunbeam is at first perfectly plain and vivid in the air of the room. If all disturbance of the air be avoided, the luminous track will become fainter and fainter, until at last it disappears absolutely, and no trace of the beam is to be seen. What rendered the beam visible at first? The floating dust of the air, which, when thus illumi-

nated and observed, is as palpable to the sense as dust or powder placed in the palm of the hand In the still air, the dust gradually sinks to the floor, or sticks to the walls and ceiling, until finally, by this self-cleansing process, the air is entirely freed from mechanically suspended matter."

By further experiment he also proved that a dustless atmosphere is always disassociated from infection of atmospheric origin, that "in all these cases you find the dust invariably producing its crop of bacteria, while neither the dustless air nor the nutritive infusion, nor both together, are ever able to produce this crop, your conclusion is simply irresistible that the dust of the air contains the germ of the crop which has appeared in your infusion. I repeat that there is no inference of experimental science more certain than this one."

These facts are made use of; dust particles are now removed by ventilation or by washing walls and furniture and finally allowing the remaining dust to settle, when it may be removed by flushing walls and floor with sterilized or antiseptic solutions. For this reason most operating rooms are now constructed of highly polished and impervious materials, such as marble, which admit ready removal of dust by such means. Kuemmel has shown that a dustless operating room can be obtained in a well appointed hospital and Neuber has shown that most excellent results can be obtained in operations under such conditions—even without the use of antiseptic solutions, provided the hands, instruments, dressings, etc , be thoroughly sterilized. But

such ideal surroundings cannot always be secured, indeed it is almost impossible outside of the hospital with its special equipment for just such purposes. It is practically impossible to escape dust in inhabited localities, no matter how cleanly the domicile—indeed, the general practitioner will have to do most of his surgical work, such as it is, in more or less dusty surroundings. Therefore we are forced to employ irrigation to remove the chance or opportunity for such accidental infection. Gerster says: "But even a constant and powerful stream of fluids will not be able to dislodge all the particles of dust that may have settled down upon and insinuated themselves into the nooks and crevices of a wound. Hence it is desirable to employ a liquid that, aside from its non-irritant quality, will have the property of extinguishing the noxious effects of those particles of dust that can not be washed away by the irrigation, but remain imbedded in the tissues. *This is chemical sterilization.*"

While these things which confront us are conditions and not theories, yet, as we have previously stated, of vastly greater importance and of vastly greater frequency is that form of infection termed contact infection. This may be caused in myriads of ways, by the mere contact of unsterilized objects of any kind, whether such be the instruments, the sponges, the dressings, pledgets, or the hands of nurse or assistant, or even of the operator himself. To guard against such form of infection not only must the wound or site of operation be as thoroughly sterilized as possible but all objects

brought into contact with the wound, or with objects which are to be brought into contact with the wound, must be thoroughly sterilized as well. Infection by all channels, whether direct or indirect, must be thoroughly excluded. Upon this point we lay greatest stress, for only in such manner can thorough antisepsis or asepsis be secured. It is a trite old adage, but one well worthy of repetition here, that "What is worth doing at all is worth doing well." Of nothing is this so true as of antiseptic and aseptic procedures, because the sin of the surgeon becomes two-fold—the sin of omission of thorough sterilization develops directly into the sin of commission of infection. And woe to the unfortunate operator in such a case—who will shrive him from his sin? Is he excusable for ignorance? Is he excusable for carelessness? Granting these facts, are we not forced to face the issue?

Such conditions as we have described do undoubtedly exist—do we possess a remedy? Is it within our power to efficiently and thoroughly sterilize or disinfect everything which is liable to come into contact with the wound? The reply of Kocher to this question could hardly be more emphatic: "This question is to be answered unhesitatingly in the affirmative as regards pledgets, dressings, sutures and instruments, and a physician is no longer permitted to sin against the demands of absolute sterilization of the objects named or to excuse defects in the antiseptic treatment of wounds by untoward external conditions."

By what means can we secure antisepsis and asepsis?

There is a large number of drugs possessing disinfecting power and with each moment the list increases interminably. Foremost among all of these agents stands carbolic acid, the substance to which antisepsis owes its birth; the *protege* of Lister, cast aside but only to be received back again with ten-fold welcome when a riper experience had but served to confirm his first views. Suffice it to say that carbolic acid is used exclusively by Lister, Annandale and other eminent operators. Mercuric chloride (corrosive sublimate) was formerly held in high favor but the experiments of Geppert, Tavel, Vicquerat, Zimmerman, Kelly, Welch, Robb, Ghriskey, McClintock and others all uniformly demonstrate that the germicidal value of the medicament was much overrated—indeed, it is now considered to possess little if any germicidal power, certainly less than that of carbolic acid, although its inhibitory power is high. Many operators have abandoned its use for carbolic acid and from a voluminous correspondence with many of the most prominent surgeons of America, Germany, France, England and Austria, I learn that many who use the sublimate restrict it to cleansing the skin in the vicinity of a projected operation.

The sterilizing agent *par excellence* for instruments and dressings is heat. Satisfactory sterilization of gauze, ligature and instruments can be secured by exposure for comparatively short periods to moist heat at a temperature at or slightly above that of boiling water. At temperatures of 266° Fahrenheit, and above, all micro-organisms and their spores present in permeable ob-

jects are absolutely destroyed in a very few minutes. At many of the surgical clinics in this country and in Europe the steam or hot water sterilizer has become one of the most important adjuncts to the armentarium of the surgeon. The best, simplest and most accessible substitute for steam is boiling water. It was Davidsohn who taught us to sterilize instruments by boiling. It was he who demonstrated that even the boiling of instruments for five minutes, in covered vessels charged with water, was followed, not once, not twice, but *invariably* by perfect sterilization of the objects so treated. This may be continued for a longer time if desired, indeed the longer the better, within certain limits. We may feel assuredly confident, however, that we are using properly sterilized instruments when they have been immersed for half an hour in boiling water; but the great drawback to such boiling, especially when prolonged, was that all steel instruments were invariably rusted and ultimately ruined. To the ingenuity of Schimmelbusch we are indebted for an expedient which, though simplicity itself, effectually overcame all objection on this score. He suggested the use of a one per cent aqueous solution of sodic carbonate ("soda") in place of water alone; this prevented the much-dreaded rusting. The advantages of such methods of sterilization are immeasurable in many respects; probably one of the most important is the simplicity of the process, and the apparatus as well, to say nothing of the ease with which the latter may be obtained and the former applied almost anywhere.

It is interesting to note that Tavel has demonstrated that solutions of sodic chlorid (common salt) and of sodic carbonate (soda) require much less boiling for complete sterilization than simple water. Therefore the addition of soda to water, as suggested by Schimmelbusch, to prevent rusting of instruments, in the process of sterilization is not only beneficial in such respect but also actually hastens and perfects sterilization. Tavel has shown that a solution of 0.75 per cent of salt and of 0.25 per cent of calcined soda is absolutely sterile after fifteen minutes' boiling (killing various spores, among others those of the bacillus of anthrax and of the hay bacillus); this solution also keeps very well, only a few mould fungi developing at the end of an exposure of several weeks, it is claimed. Gauze compresses, pledgets and silk Tavel claims to have rendered absolutely sterile by boiling them half an hour in the solution. He furthermore demonstrated that such solution was unirritating to wounds and to the peritoneum and hence, in his opinion, formed an excellent non-irritating and absolutely sterile solution, when so boiled, which seemed to be especially adapted for purposes of aseptic irrigation.

Perhaps it might behoove us to give some consideration to a few of those points, purely technical in nature, by means of which success is attained—*per aspera ad astra.*

Cleansing of the Patient and Sterilization of the Wound Area and Vicinity.

Many surgeons give, where practicable, one or more warm baths preceding the operation. In the early days of antisepsis Volkmann thought that shaving and scrubbing of the skin in the neighborhood of the proposed operation should precede all other measures with a view to disinfection. There cannot be the slightest doubt, in fact time has but comfirmed his practice, that the powerful adjuvants of razor, soap, stiff brush and hot water are of the most desirable nature. We know that masses of filth, cutaneous debris and of pathogenic and pyogenic micro-organisms cling to the epidermis and especially in those regions most covered with hair; furthermore, such collections are permeated by the natural sebaceous secretions of the cutaneous glands, such coating forming an effectual barrier against the penetration of watery solutions of antiseptic medicaments, with the probable exception of carbolic acid. Schimmelbusch has demonstrated the inhibitory effect of such unctuous materials upon the action of chemical sterilizers in aqueous media. Therefore some means must be used for the removal of such objectionable substances. To effect this the area is shaved, if hairy, removing at once mechanically a great number of organisms as well as conditions favoring re-infection. Then thorough scrubbing with potash or soft soap, hot water and a stiff bristle brush sweeps away with rapidity and facility, grease, filth, cutaneous debris and noxious micro-organ-

isms, leaving for the action of subsequently applied antiseptics but a minimum amount of work to do.

Not only must we sterilize the wound area in the manner just indicated but it is obligatory that we look strenuously to the means by which we accomplish our objects. Among the various articles used for such purpose probably none is so exposed to infection and is therefore so liable to become a dangerous though unconscious focus of infection as the surgical nail brush. Schimmelbusch has made extended investigations and experiments in the cleansing and sterilization of such brushes. He has positively shown that the common method of a single brief immersion, in even a strong germicidal solution, is hardly more than merely perfunctory in nature, it is entirely inadequate to destroy the adherent pathogenic and especially the pyogenic micro-organisms and, moreover, inspires a confidence which is entirely false and which can be naught else than baneful in effect. Upon examining the brushes so treated in the Berlin clinic Schimmelbusch found them to be especially rich in pyogenic bacteria; he also demostrated that an immersion of at least ten minutes duration and made in a strong mercuric solution was absolutely necessary. This was true when the brushes so sterilized were entirely free from the soap used in scrubbing. But more frequently than not the brushes are thrown back after use, fairly reeking with soapsuds aud infectious material, the soap rendering the sublimate entirely inert and the infectious material converting what should be a haven of safety into a masked and

uncertain, and therefore doubly dangerous focus of infection. Therefore where sublimate sterilization of brushes is employed it is imperative that all soap should be cleansed from them before immersion in the sublimate solution, otherwise perfect sterilization cannot be effected. On this account it is a source of great gratification and congratulation to learn from the researches of Schimmelbusch that simpler and far more reliable means of sterilization are within the reach of every physician and surgeon. He has proven that the most unclean brush can be rendered absolutely and indubitably aseptic by simple boiling for five minutes in a one per cent aqueous solution of soda.

With such simple, effective and accessible means for the sterilization of surgical nail brushes at our disposal there cannot be the slightest shadow of an excuse for neglect in this direction, nor indeed can there be for culpable neglect anywhere in the chain of antiseptic or aseptic procedures essential to every precise and scientific operation.

Cleansing and Sterilization of Instruments.

No one can doubt for an instant that the removal of such debris as pus, blood, portions of animal fibres and tissues and what not which inevitably cling to all instruments used in the course of an operation, should be thoroughly attained before use of such instruments for operative work again. We do not think that even the most conservative adherents of the old-fashioned methods could or would gainsay the fact that such precaution

is only proper and legitimate—nay, even demanded. But what of the instrument which has come in contact with infected tissues, instruments which have bathed and reeked in the morbid discharges or tissues overwhelmed by erysipelas, by tuberculosis, by syphilis or by an infectious affection of any nature? Is the necessity for purification of these instruments not greater, incalculably greater, than in the case of instruments which have traversed only perfectly normal and uninfected tissues? However, it has been demonstrated by Schimmelbusch that even the most careful, thorough and extensive scrubbing and washing of instruments with hot water, soap and a stiff brush does not and can not render them aseptic if they have been once infected. To many, especially artery forceps and other purposely roughened instruments, considerable and dangerous quantities of harmful germs were found adherent. It is necessary to do more than merely wash the instruments, no matter how thoroughly the latter process is conducted. Simplicity in an instrument is now, all other things being equal, the most desirable quality. The very best and certainly the very safest are the simplest, those fashioned entirely of one piece of metal and having no crevices and interstices to offer favorable lurking places for infectious material. They should, moreover, possess smooth and well-polished surfaces—no grooved or otherwise roughened handles; they are unnecessary, they are hard to clean thoroughly and what is more they directly invite and favor collection of infectious material and hence increase chances of

septic infection in operative work. As Gerster says: "Another factor has to be considered. In the large practice of our hospitals, where from three to five operations are performed at one session, the minute cleansing of a large instrumentarium after each operation is tedious, involving considerable time. We either had to submit to this, or had to provide a disproportionately large and costly set of duplicates and triplicates. As a matter of fact, the latter thing was rarely resorted to, and the cleansing of the bloody instruments being hurriedly and often inadequately done, main reliance was placed upon the disinfecting power of our carbolic acid bath. And as consideration for the assistants' hands had gradually caused the abandonment of the stronger for weaker solutions, frequent failures in securing primary union were the result of these evasive attempts."

How different and how much more certain are the conditions at our disposal at the present time! All that we need is a covered vessel containing a one per cent aqueous solution of soda; after boiling the instruments therein for five minutes we may empty them into sterilized water or, better, a 1:20 or 1:30 solution of carbolic acid. They are thoroughly sterilized and are ready for use. In many hospitals cold sterilized soda solution is kept at hand to be poured over the hot instruments upon placing them into the tray. Sterilized water is also frequently employed for the same purpose.

We may then sum up the requisites for thorough sterilization of instruments to be used in operative work as follows:

a. A thorough preliminary cleansing with a stiff brush and plenty of soap and hot water.

b. After such preliminary cleansing all instruments are to be boiled for at least five minutes in a covered vessel containing a one per cent aqueous solution of soda. All instruments, complex in nature, which for any reason cannot be subjected to thorough preliminary cleaning, or which have been exposed to specially virulent infection, should for caution's sake be boiled for half an hour.

c. After such sterilization is completed the instruments should be placed in a tray of three or four per cent carbolic acid solution to guard against infection before use.

NOTE.—All instruments dropped during an operation should be left untouched unless re-sterilized.

PREPARATION AND STERILIZATION OF DRESSINGS.

The dry preservation of dressing materials sterilized and impregnated with phenol or sublimate must be entirely rejected. Not that these substances possess no value but that such sterilization is but ephemeral at best in the case of dressings which are not used within a reasonably short time after subjecting them to such means of sterilization. Phenol is more or less volatile and sublimate is rendered inert by long continued contact with organic matter. Sterilization can only exist as long as these agents are present in active form. Kocher says that positive demonstrations show that such is not the case with dry dressings chemically

sterilized, unless the materials are applied directly to the wound from the antiseptic solution. We cannot be sure that such dressings have not become re-infected after the antiseptic agent has volatilized or become inert.

When we consider the large quantities of fabrics handled by the large number of persons required by the folding, immersing, wringing, unfolding, drying, refolding, cutting and final storing or preparation for shipment; when we also consider the fact that the workmen are necessarily devoid of the technical knowledge of asepsis and the minutæ of conditions required by the surgeon in aseptic work, we must be forcibly struck by the chance of possible accidental contamination. Necessarily the manufacturer's standard is one more or less commercial in nature, the essential requisite *to him* is profit and yet he must also meet competition; therefore the work must be conducted by individuals to whom the requirements of surgical accuracy are matters of utter indifference, if indeed they be not also matters of utter ignorance. It is obligatory, it is essential that we assure ourselves beyond a peradventure that all dressings are actually sterilized before employment in wound dressing. We surely cannot credit such an ideal to all dry dressings supplied by manufacturers. Not that their use should be forbidden but that they should not be accepted as sterilized when such evidence is based solely upon the *ipse dixit* of the manufacturer; he is surely not going to make derogatory remarks about his own products, and even where he is thoroughly consci-

entious the chances of infection, both while in his hands and afterwards, are utterly beyond his ken. Therefore if we do employ such dressing materials we should make assurance doubly sure by re sterilization. No better directions for such process can be given than those offered by Dr. Gerster in a recent paper on "Aseptic and Antiseptic Details in Operative Surgery;" we quote him *verbatim:*

"For purposes where a reliable dressing has to be procured, *extempore* boiling in a soda or potash solution of about 1½ per cent for ten minutes is incomparably the simplest and most practical manner of getting an absorbent and aseptic material. In this procedure we recognize at once the familiar ways of the laundry, the eminently aseptic results of which have been demonstrated beyond any reasonable doubt by Behring in the Berlin Hygienic Institute. Thus cotton or linen stuff, to be found in every household, can be readily rendered serviceable for surgical purposes by a short boiling in soda or potash lye. Well wrung out, it can be immediately used, and will dry rapidly *in situ* under the influence of the body heat and exposure to the air."

Sterilization by means of hot air has also been suggested and employed but, as Gerster says, has not received consideration because of the necessity of costly and complicated apparatus. Then, also, there can be no question but that the methods of sterilization by employment of *moist* heat are vastly more efficacious and vastly more simple than those by dry heat. These objections, therefore, do not obtain against the employ-

ment of steam for purposes of disinfection or sterilization.

Preparation and Sterilization of Ligatures and Sutures.

It must be obvious that infection of wounds may happen through the medium of improperly prepared ligatures and sutures, or where incompletely sterilized or even non-sterilized gauzes or other bibulous or porous materials are introduced into wound areas—even though for the purpose of absorption of discharges and consequent local drainage. Suppose, for example, that infectious material has been introduced by means of a suture; we have then transplanted into the wound an absolute and positive focus of incubation, proliferation and infection. The micro-organisms find in the injured tissues, altered secretions and morbid discharges highly appropriate media for development. We have here conditions most favorable for a progressive, lasting and spreading infection.

For such purposes as ligation and suturing, silk, catgut and silkworm gut are the materials most frequently employed. Well prepared catgut of suitable sizes may, at times, be used for both. Probably one of the best methods for effectively and conveniently sterilizing catgut is that recommended by Kocher:

Wash the commercial article in ether and then immerse it for twenty-four hours in good oil of juniper *berry;* it may then be transferred and kept ready for use in a 1:1000 solution of sublimate, the medium of solu-

tion being absolute alcohol. The absolute alcohol, of course, hardens the catgut, making it firm but flexible. When it is desirable to prevent a too ready absorption the article may be especially hardened, after sterilization and subsequent washing in alcohol, by immersion in a 1:20 solution of carbolic acid containing thirty grains of potassic di-chromate to the quart. An immersion of forty-eight hours duration will cause the substance to resist absorption for a week or ten days.

Silk may be boiled, as Czerny, of Heidelberg, directs, in a 1:20 carbolic acid solution for one hour, or else immersed for twenty-four hours in a solution of corrosive sublimate in alcohol (1:100) and then kept for subsequent use in absolute alcohol.

Silkworm-gut is easily threaded and moreover makes an excellent suture material. It may be prepared in the same manner as silk. A preliminary soaking, before use, in carbolic acid solution is said to render it more pliant and supple.

Ligature materials, after chemical sterilization, should be wound upon spools of glass or other easily sterilized material and preserved by immersion in antiseptic solution from which, when desired for use, they should be directly transferred to the wound. This latter procedure is allowable because the amount of adhering phenol or sublimate is small and of no importance as far as fear of toxic effects may be concerned; indeed the practice so far from being reprehensible is probably of decided advantage in that it effectually eliminates the chance of accidental infection at the time of its employment.

In the Billroth Clinic in Vienna, the silk is preserved in closed vessels in five per cent aqueous solution of carbolic acid; the silver wire in carbolic glycerin of ten per cent strength; the catgut in sublimate alcohol of one per cent strength; all are put into a two and a half per cent carbolic acid solution before use and are handed out of this. In order to make sure of avoiding any interchange, the instruments which are used in phlegmon, etc., are kept in a special wooden box by themselves and are conspicuously differentiated from the rest by means of their handles.

Preparation and Sterilization of Sponges.

These articles, in many quarters, have been supplanted by pads or compresses of absorbent cotton or gauze, because of the cheapness and comparatively easier methods of disinfection of the latter. Indeed many operators of distinction have altogether abandoned the use of marine sponges. Dr. W. W. Keen writes me thus: "I have practically abandoned marine sponges, and use sponges made of dry bichloride or sterilized gauze, rolled into balls about the ordinary size." In the clinic of Billroth in Vienna the use of sponges in laparotomy was discarded in 1887; at the present time sponges have been almost entirely supplanted, even in other operations, by sterilized gauze compresses of various sizes. Gerster also says:

"The large flat sponges so generally used in laparotomy have been abandoned by me for three years as expensive, and not as handy as small, well-sterilized com-

presses of plain, absorbent gauze, which, to prevent unfolding and fraying, are firmly tied with silk at one end. The surgeon is nowhere so cramped for lack of space as at his operations in the bottom of the pelvis. A sponge used for packing away intestines needs constant pressure to prevent its expansion and encroachment upon available space. A pad of gauze held down for a short while will become packed, and will retain its shape and position even if released from digital pressure."

Nevertheless for some purposes sponges, properly prepared, are peculiarly adapted and, as they are used by some surgeons yet, it may not be out of place to give some space to their consideration. Among other measures which have been suggested is boiling; such a method is foolish in the extreme, because the process of sterilization by boiling robs the sponge entirely of those very properties which render it valuable, materially impairing its absorptive powers, its softness and its elasticity.

Many operators bleach their sponges before using them, this is not essential but adds to the appearance. A good and reliable method of preparing and sterilizing sponges is as follows:

a. Free the sponge from calcareous materials by dry beating and then immerse for about fifteen minutes in dilute hydrochloric acid. Then wash in cold water until all traces of the acid have been removed.

b. After removal of calcareous matter, as directed, allow the sponges to stand a couple of days in water.

This will allow proliferation or germination of spores —the fully developed microbe being much more susceptible to chemical sterilization than the spore. After such standing the sponge is more thoroughly and effectually sterilized.

c. Thoroughly knead the sponge by hand with green soap and plenty of hot water for several minutes. Rinse away completely all traces of soap.

d. Immerse in a five per cent solution of carbolic acid. An immersion of twenty-four hours, after such treatment as has been described, is said to render sponges absolutely sterile.

After squeezing the sponges until free from excess of sterilizing solution, they may be preserved in sterilized air-tight jars until needed for use. Before using they should be immersed for awhile in a five per cent solution of carbolic acid.

Sponges once used may be re-sterilized by the same process; in case of saturation with blood they should be well washed in tepid water until all traces of blood have been removed.

Sublimate should never be used for sterilization of sponges—contact renders it inert, especially in the presence of light and heat.

As a rule sponges are only used in operations requiring rapid absorption of blood or secretion and more especially in those cases where total arrest of hemorrhage is only possible by rapid completion of the operation. They are especially of service, fastened to sponge or artery forceps, in certain operations about the face, the

vagina, etc. They are also of great service in the rapid cleansing and preliminary tamponade of the intestinal canal in abdominal work.

Preparation and Sterilization of the Hands.

Of equal importance for the attainment of success is sterilization of the hands of the operator, his assistants and his nurses. Kuemmel and Fuerhringer have both shown that enormous quantities of pathogenic and pyogenic organisms are constantly lodged upon the hands and especially beneath the finger nails of even the cleanest of individuals,—this is particularly true of physicians and surgeons, as well as of all others directly exposed to infectious materials. No amount of washing, or scraping, or trimming of nails can absolutely remove these germs, more especially those lodged beneath the nails. To facilitate digital examination the finger is frequently lubricated with some oleaginous substance; this collects in the space beneath the nail, so also do the various germs with which the examining finger necessarily comes in contact; they are finally crowded into and stored away in the space beneath the nail, firmly ensconced in the greasy collection and thereby effectually protected against penetration and action of antiseptic solutions. Therefore certain preliminary measures of cleaning are necessary, as in the case of the sterilization of the skin of the patient in the vicinity of the wound.

The hands, forearms and nails of operator, assistants and nurses should be thoroughly washed and scrubbed

in soap and hot water with a stiff bristle brush for five or ten minutes. The nails should then be trimmed and scraped, especially in the subungual space, and re-scrubbed. Kuemmel recommends green or potash soap for this purpose; this is an excellent suggestion as to the detergent action of the soap is added the antiseptic action of the usual excess of alkali in such soaps.

For the sake of safety it is better that an operator, or his assistants, should not wear rings during an operation; they should be taken off before the hands are scrubbed and remain off until the operation is entirely completed. It would also be wise to caution nurses, as Gerster suggests, against the wearing of bangles, rings or bracelets. One thing should be thoroughly impressed upon all assistants and nurses—whenever a non-sterilized object of any kind is touchad, no matter what its nature, it is imperative that the hands be sterilized anew.

But as to the method of sterilization. Thanks to the use of steam and boiling water we have attained absolute security in the disinfection of inanimate objects. Unfortunately, however, such absolute precision has not been attained in the sterilization of the hands, of the skin of the patient or of his tissues—nevertheless such is a necessity in the antiseptic and aseptic methods of wound treatment. We cannot hold our hands in the streaming stream, nor can we immerse them for five minutes in the boiling soda solution and certainly we cannot subject our patient to such measures. Hence for the preparation of hands and skin we are forced to the

adoption of a combination of mechanical and chemical sterilization. Bacteriological examinations by Tavel and Vicquerat show that the hands are usually rendered sterile by the method suggested by Fuerbringer. But this is by no means always reliable notwithstanding the great degree of confidence which it enjoys, for if the operator has been exposed to infection (a condition in which sterilization of the hands becomes more imperative than ever), the method does not succeed in effecting sterilization. In order to test this Kocher opened a large abscess and purposely soiled himself with the discharges. In spite of thorough application of the method of Fuerbringer, colonies of staphylococci subsequently developed. Kelly at Johns Hopkins University and Welch of the same institution have both proven that the method is unreliable—and especially in those cases when its use would be most desirable. They have given a great deal of attention to this subject and have suggested a more exact and certain method of manual sterilization which was fully discussed in a previous paper. For the details of this most recent and most successful method of sterilization of the hands see the paper "Antisepsis in Obstetrics."

Irrigation.

Upon this subject of irrigation a war of words has been waged *pro* and *con*. Nevertheless it is too important to be dismissed without some adequate notice,—by some it has been damned while by others it has been canonized.

All operative work is preceded by certain essential and preliminary measures, such as the securing of a dustless atmosphere, thorough cleansing of the skin of the patient and of the hands of operator, assistants and nurses, thorough sterilization of instruments, sponges, dressings, etc. Were these preliminary measures always uniformly and ideally successful then irrigation would be unnecessary. Unfortunately this is not altogether so, but as we progress towards the attainment of that ideal state the need of irrigation becomes more and more restricted. But as long as there is a chance for a flaw, as long as there is even ground for suspicion, just so long is irrigation an absolute necessity.

It is usually impossible to secure a perfectly dustless atmosphere for operative work; therefore in order to remove infectious material, whether from air or morbid substances derived from the organism itself, irrigation is usually employed. Moreover we must not forget the chances of accidental infection by inattention, they can hardly be excluded but are to a certain extent anticipated or guarded against by irrigation. Indeed in many instances irrigation is most valuable, bridging over what would be culpable gaps in an otherwise complete and faultless procedure. Suffice it to say that in regions which can be rendered aseptic with difficulty it is an indispensable adjunct to the surgeon.

Irrigation may be either aseptic or antiseptic in nature—aseptic when simple, bland, sterilized solutions are employed; antiseptic when the irrigating fluids are vehicles of antiseptic or germicidal agents. The vir-

tues of irrigation may therefore be ascribed to either a chemical action or the mere mechanical cleansing effect of the stream injected against or over the tissues—or may be ascribed to a combination of both. It is interesting in this connection to note the experiments of Zimmerman and Tavel. In their experiments small pieces of meat were infected with definite micro-organisms; it was subsequently found that attempts at sterilization of such infected particles were by no means always successful, even though the fragments of meat were immersed in a 0.1 per cent acid sublimate solution from one to five minutes. On the other hand, sterilization was easily effected under the same conditions when infected strips of blotting paper were used in place of the fragments of meat. If then this contact of the strong antiseptic solution was insufficient to effect sterilization we can hardly hope to secure better results from the momentary contact in the case of wound irrigation. In practical work micro-organisms are not usually found in surroundings which are ideal as far as the application of antiseptic principles is concerned. We do not find them disassociated from organic material. As Gerster says, they are not met with in the shape of thin, watery emulsions but are found imbedded in dense masses of what Lister appropriately called "lumps of dirt," in conglomerations of grease and epidermis, in powerful plugs of sticky slime, pus and blood clot. Therefore let us first emphasize the paramount antiseptic value of the homely methods employed for cleansing dirty surfaces, comprised in the term *mechani-*

cal purification; and secondly point out how infinitely more they accomplish than any form of chemical disinfection by watery germicidal solutions *alone.* Both should be combined. Still, as Kocher points out, Zimmerman obtained quite an important difference in degree by his disinfection, since a lesser number of colonies developed and these did so more slowly and at a later time, their virulence having been weakened. Therefore Lister, considering every wound to be theoretically more or less infected, washed it with 0.2 per cent sublimate solution at the end of an operation; he has lately, however, discarded all other antiseptics in favor of carbolic acid. Many surgeons modify this process of antiseptic irrigation by final flushing of the wound area with a 0.75 per cent sterilized salt solution in order to wash away all trace of the antiseptic.

Irrigation is now rarely employed in aseptic wounds, it is not only unnecessary but may even prove, as has been declared in some instances, actually harmful; it is therefore to be restricted to conditions or wounds which are not in a thoroughly aseptic condition, such as those in the neighborhood of the orifices of the body or in the vicinity of accidentally infected or actually suppurating areas. Gerster says: "*A notable exception to this rule is the abdominal cavity, wherein irrigation is never to be employed.* This statement seems to condemn a widely spread practice, and some courage is needed to express it unreservedly. * * * How entirely useless, nay, pernicious, the effects of flushing the peritoneum are in cases of active septic infection, as, for instance, in the

presence of fetid fecal abscesses due to intestinal perforation, has been abundantly demonstrated to myself and to other surgeons here and abroad by numerous unsuccessful attempts. And there is nothing more certain than that, on account of its complex character, the peritoneal cavity cannot be completely washed clean; that germicidal solutions cannot be used in a sufficient strength to be effective, and that finally an inert or weak solution will only help to spread the elements of infection to previously unaffected areas. The substance of these assertions was essentially confirmed by experimental research on animals."

As to opening large cavities of the body, it seems that no proof has been as yet offered that successful results cannot be attained by the employment of proper precautions both before and after an operation, even though antiseptic irrigation be discarded. Indeed it may well be said, as has been done, that most operations within the peritoneal cavity afford no very rigid test of the absolute value of the aseptic or antiseptic measures therein employed. The condition of the serous membranes and cavities, especially when exposed to infection through various channels, is by no means a proper and infallable guide for other injured tissues under the same conditions, such for example as muscular or areolar tissue. The tolerance of the peritoneum is well known and seems almost incredible; therefore technical faults committed during abdominal operations are much oftener undetected and unpunished by septic developments than is the case in those similarly in-

curred in extra-peritoneal operations. Because of this, Kocher and many other surgeons now restrict themselves, in abdominal operations, to antiseptic precautions before and after the operation rather than during its course, and discard antiseptic irrigation trusting the care of the wound during the operation to asepsis and to the inherent resistive power of normal tissue. Numerous experiments seem to demonstrate that the serous membranes are remarkably tolerant of infectious materials or else digest them with relative facility, thereby rendering them harmless, perhaps, as has been suggested, by the assistance of serous transudation. But this remarkable tolerance, as has been shown by Walthard and Tavel, exists only so long as the endothelium remains intact. The injured tissues encountered in a traumatism are by no means in this favorable condition; therefore the tolerance of the peritoneum should never be allowed the function of a cover beneath which to hide imperfect, careless and slipshod work. In laparotomy as well as elsewhere—indeed if not more so—the employment of thorough, rigid and conscientious anti sepsis and asepsis is obligatory, it is naught else than a duty. As has been said, once overstep the limit of peritoneal tolerance and the danger usually becomes irretrievable—the life of the patient usually terminating by a septic peritonitis for which there is no redress.

Drainage.

Many of the remarks made as to irrigation apply with equal force to drainage of wounds. As Gerster most

tersely says: "Imperfect cleanliness, copious irrigation and abundant drainage represent the links of a chain forged by necessity. A faultless asepsis has often enabled us to do away with both irrigation and drainage."

One of our best auxiliaries in securing the rapid healing of wounds is to render development and proliferation of infectious material an impossibility—although we also must be mindful of the fact that such conditions do not and cannot obtain in perfectly aseptic wounds. It must be remembered that normal healthy human tissues, and especially those through which the blood and lymph are circulating freely and properly, constitute very poor media for micro organic development,—indeed there can be very little doubt but that such tissues are endowed with more or less inherent germicidal power, as we have shown in a previous paper. But the stagnation and subsequent alteration of blood or serum offer excellent culture media and therefore it becomes a duty to institute, in other than aseptic wounds, such processes as will tend to prevent the accumulation of altered secretions or morbid discharges in the wound area. This we can secure in two ways; that is, either by exact coaptation of well-nourished wound margins or else, where this is not possible, by removing secretions and conducting them without the wound area. This last condition may be secured by the open method, the method of secondary suture or else by drainage direct. In the first, the open method, healing will be slow; in the second or method of secondary suture, employed

and modified by Bergmann, Nussbaum, Spengler and Helferich, the wound is left open for one or two days and then closed by sutures—it is claimed to unite the advantages of the open method and that of exact coap tation; the third method is that of drainage by means of drainage tubes or gauze. These tubes are seldom allowed to remain in the wound longer than forty eight hours, except in case of grave infection.

Theoretically we may say positively that drainage is useless in a perfectly aseptic wound. If the wound is aseptic the secretions following an operation or an injury contain nothing capable of causing sepsis, they will be absorbed with no disagreeable consequences and with no disturbance to either the wound or the general health of the patient. But in the event of exposure of large surfaces and irregular wounds a slight contamination is usually to be foreseen and expected, as well as met by proper means; these are usually afforded by proper drainage tubes allowing facile discharge of all possible elements of future decomposition and infection.

Small superficial wounds, where complete approximation of the wound surfaces can be secured, do not need drainage. But deeper wounds, such as may be adapted for either complete or partial primary union, must be drained so that secretions may not accumulate after union and compression have been instituted. In these cases drainage by tubes is probably preferable. Drainage is also indispensable in all acute, progressive, suppurative processes where an egress may thus be provided for pus, sloughing tissue and morbid discharges.

Probably nothing is in every way better adapted for such purposes than the pure black gum or caoutchouc tubing cut into proper lengths and preserved in an up right position in a 1:20 carbolic acid solution.

It can be engraven upon the memory that properly prepared aseptic rubber tubes are seldom, indeed we may say never, capable of causing irritation. Any increased discharge or other untoward phenomenon is due to infection introduced within the wound by some means, usually by means of the tube itself. In aseptic wounds the function of the drainage tube is gone at the end of about twenty-four hours because oozing has usually terminated by that time; although it is more frequently kept in until the change of the first dressings in order to avoid the disturbance of wound and dressings consequent upon the removal at an earlier period.

But we repeat, in perfectly aseptic wounds drainage is unnecessary, unless discharge is excessive. Gerster goes even beyond this, he says: "Even in operations where we are not absolutely certain of the aseptic condition of our wound we can often dispense with the use of drainage tubes, and not incur any serious risk. Bergmann first demonstrated that a wound of doubtful asepticity can yet be made to heal by primary adhesion. He passed his suture points through the edges of the wound and all its recesses down to the bottom with iododoform gauze. Over this was placed the usual outer dressing. Through the capillary action of the gauze copious oozing of serum was encouraged, which in about sixty hours lost its sanguinolent character, whereupon

the packing being extracted the suture points left *in situ* were closed, and the wound was seen to heal in a manner little differing from primary union. Undoubtedly, much of the success of this plan of packing and secondary suture is to be attributed to the iodoform, which has triumphantly withstood various attacks upon its reputation."

Still another modification of this form of drainage is now extensively employed in abdominal surgery, where, on account of much unavoidable denudation or accidental infection, copious oozing is to be expected. Mikulicz was the first one to employ the iodoform gauze packing successfully in the abdominal cavity, and his plan has met with widespread and deserved acceptance. First, it does away with the use of the drainage tube, and secondly, its contact with the peritoneum causes just enough adhesive irritation to insure after its removal rapid agglutination of the raw surfaces. Immediate closure of the wound can be practised after the extraction of the packing.

Thanks also to Schede's method of treatment under the moist blood crust we have, as it were, the choice of a middle course between the open treatment and drainage. Kocher says of it: "When the immediate coaptotion of the wound margins is impossible it utilizes the blood effused into the wound to fill the cavity. The wound is allowed to fill with blood, the edges are but partially united by sutures, and the rest is covered with impermeable tissue. Where neither primary nor secondary suture is possible this method is much preferable

to the simple open wound treatment, with reference to the duration of the healing, by favoring the cicatrizing process."

But more frequently than not all of these agents and means which we have described are applied in operative work where the wound is made by the surgeon himself and most of the conditions are directly under the control of the operator; hence it is more possible to secure asepsis, to prevent an intense or prolonged infection. There are times as well when one must operate under other than these favorable circumstances, when extensive micro-organic invasion of the tissues has already occurred or else when such invasion cannot well be avoided, or when the site of the operation is also the focus of an infection which is either intense in nature or long in duration. In such cases we have to vary the treatment with the conditions to be met; more frequently when such wounds are not aseptic we can secure very good results by the use of antiseptic irrigation of the wound area, the application of moist chemically sterilized compresses or other dressings which are frequently changed unless specially contra-indicated; then the wound can be sutured after the infectious matarial has been eliminated and the line of union, in fact the whole of the wound area, dusted with a dry antiseptic powder dressing.

Mosetig von Moorhof, by the use iodoform in 1880, introduced a new form of wound treatment. Iodoform, *per se*, is a comparatively bland and inert body; but contact with decomposing organic matter effects its own de-

composition, liberating free and elementary iodin by which the ptomaines and toxalbumins are fixed and incidentally further micro-organic development arrested, as De Ruyter has shown. Both of these effects are due to the presence of the liberated iodin rather than to iodoform itself. This peculiar effect is only possible in the presence of decomposition and such products as ptomaines and toxalbumins. But the latter are directly the result of vital activity on the part of bacterial organisms, any condition in which they are found must necessarily be septic in nature; therefore iodoform would be practically and antiseptically inert in an aseptic wound. It is for this reason that Kocher says that iodoform has no place in the aseptic treatment of wounds. In wounds appropriate for the aseptic treatment he further says that its employment is senseless; on the contrary, the wound may be directly infected by its application. But it is the most active of all drugs for counteracting beginning and advanced decomposition and hence is to be used on wounds where decomposition must be expected from insufficient asepsis. Bergmann's mode of using the drug has been shown by the investigations of De Ruyter to be the best—namely, to pour into the wound a solution of iodoform (ten parts) in ether (twenty parts) and alcohol (eighty parts).

Dry Pulverulent Dressings.

All modern wound or other surgical dressings have in view one primal, or rather a two-fold object, namely the exclusion of germs or their destruction or inhibition when access has already taken place.

Albuminoid substances, such as the blood, serum and various tissues of the body, will decay or become putrid under certain conditions. The active causes of such decomposition are micro-organisms; for the growth and development of such organisms certain definite conditions, or combinations of conditions, must pre-exist, for micro-organisms are no less amenable to vital and natural laws than the higher and more complex organisms, up to man himself,—as Browning says:

> "From life's minute beginnings, up at last
> To man, the consummation of His scheme."

Certain conditions must exist or the germ dies. For the growth and development of micro-organic life we may say that at least three conditions must co exist; these are (*a*) a certain definite temperature, (*b*) the presence of more or less moisture and (*c*) the presence of pabulum. Absence of any one will result in inhibition of vital activity if not in actual death of the germ. In the absence of the two first conditions growth and development are inhibited; absence of the last, or absence of all three conditions induce the ultimate death and destruction of germ life.

As far as temperature is concerned we have previously shown that few if any germs are really actually destroyed by even extreme depression of temperature while extreme elevation invariably effects such result. Indeed exposure for even a few minutes to moist heat at the temperature at which water boils (100° Centigrade or 212° Fahrenheit) will not only destroy almost every known

variety of pyogenic and especially pathogenic germ life but their spores as well. The most favorable temperature for their growth is from 95° to 100° Fahrenheit, that is, about the normal bodily temperature. It must be obvious that the application of a sufficient degree of heat to the body for the purpose of effecting sterilization would seriously impair and indeed destroy the vitality of the very tissues to whose normal and physiological development we are endeavoring to contribute. True the germ would be destroyed, but so also would the tissues to whose preservation and conservation our energies were supposed to have been directed. Obviously then neither elevation nor depression of temperature can be made use of in wound treatment, or in the sterilization of any infected area of the human body. Such, however, is splendidly adapted to the disinfection of instruments, bandages, dressings, etc.

As far as the second proposition is concerned, the presence of more or less moisture, this can he somewhat controlled. For this very reason absolutely *dry* operations, as Gerster and other eminent operators agree, are much more rapid in their processes of repair and healing because of the aseptic condition consequent upon such absence of moisture. This is the chief virtue of the galvano-cautery, the thermo cautery, in operative work; that the high degree of heat not only promptly destroys all germs present but also thoroughly dessicates the tissues of the wound with which the knife comes in contact, forming an absolutely dry and impervious eschar beneath which the process of repair pro-

ceeds in an almost ideal manner, because of the absence of micro organic interference with such normal process.

Gerster says in his classic work upon "Aseptic and Antiseptic Surgery:" "Small or comparatively small wounds, admitting of an exact coaptation of the deeper as well as their superficial parts by suture, are exquisitely fit for this method of treatment. Plastic operations about the face may serve as a fair type.

"Certain finely powdered substances, as iodoform or subnitrate of bismuth, have the quality of rapidly inspissating blood and serum to a dry crust. Accordingly, after the hemorrhage has been controlled and the wound closed by suture, a quantity of the substance chosen is dusted over the sutures. No further dressings are applied. The escaping bloody serum forms a paste with the powder, which by its sterilizing property prevents decomposition, while the paste remains moist. Free access of air will hasten exsiccation; and the dry, hard crust once formed will securely prevent further ingress of dust into the wound In cases where the powder is washed away by profuse oozing, the dusting has to be repeated every half hour after the operation, until the object—the formation of a dry crust—is accomplished "

Professor Friederich von Esmarch, Professor of Surgery to the University of Kiel, in a copy of his *Handbuch der Kriegchirurgischen Technik* which he recently sent me, mentions iodoform, bismuth subnitrate, naphthalin, zinc oxid, iodol, sozo-iodol, dermatol, aristol,

di iodo-thio-resorcin, sulphaminol and salol among the antiseptic powders for use as dry dressings. Of these Gerster prefers the first two. The chief objections to iodoform are, first, its disgusting, inevitable, persistent and nauseating odor; second, its feeble germicidal activity, possessing none until its decomposition liberates free iodin; third, it produces marked toxic effects in certain persons (elderly persons seem specially predisposed)—these toxic effects it seems to manifest especially upon the central nervous system and therefore its employment should be surrounded by great care and accurate dosage. It is almost indispensable, however, in the treatment of accessible tubercular areas and has, as has been mentioned, given very good results in *septic* wounds. As to the subnitrate of bismuth its chief objection is the comparative weak germicidal power. Broome, Bernays, Mastin, Martin, Senn, Marks, the author himself and a host of others have found a combination of phenol and boric acid to be a superior dry dressing. This combination (a most excellent preparation of which is furnished in Sennine) possesses in a marked degree the superior antiseptic virtues of its constituents—indeed even Lister himself now declares the supremacy of carbolic acid over every other germicide. The pulverulent and non-irritating properties of Sennine give it valuable exsiccating and inspissating powers which are absolutely indispensable in a dry dressing. Its antiseptic qualities give it valuable inhibiting and sterilizing properties; should hypersecretion by any chance supervene it is thus enabled to completely sterilize the

morbid discharges which would otherwise form a most fertile and undesirable nidus for micro-organic development. As a well-known authority upon antiseptics and asepsis has said: "Capillary attraction, exerted by a dry absorbent dressing, is perfectly adequate to drain an aseptic wound of its serous discharges and the rapid drying and crusting of these dressings is just the thing we want to seal a sweet wound against the possibility of subsequent infection from without." And just here is where the function, power and advantages of such dressings as Sennine are most desirable; complete sterilization, and the presence of the antiseptic dessicant, absolutely insure against subsequent infection.

We know that the excellent antiseptic value of our highly absorbent dressings depends as much upon their valuable qualities of promoting and hastening rapid evaporation as upon their chemical properties. We have employed exsiccation or dessication as a means of preservation for ages; for centuries men have empirically cured and preserved perishable food products in the same manner and the testimony of experience is sufficient to attest the efficacy of the process. We have discussed in detail the effect of exsiccation upon micro-organisms in a previous paper (Paper VII). It is also interesting to note in this connection that Schlange has shown that cultures, on moist pads of cotton, of the bacillus of green pus were aggressively prolific when evaporation was checked; but such proliferation was immediately stopped upon exposing the pads freely to the air and thus allowing them to become dry through

loss of moisture. Moreover, Schimmelbusch distinctly claims, with the best of reasons, that the efficacy of highly absorbing and rapidly drying dressings, *even though containing moderate amounts of schizomycetes*, is far greater than is the case with materials which lack such valuable properties *even though they be faultlessly impregnated.*

We have now reached the consideration of the third condition, namely, the presence of pabulum. Normal healthy tissue is antagonistic to the growth and development of germs; so also are normal healthy secretions. *Ergo*, healthy tissues and secretions do not contain micro-organic pabulum. Normal, healthy intra vascular blood possesses marked germicidal powers, probably due, as Vaughan suggests, to the contained nuclein or nucleins; but when such blood, drawn from the vessels, is allowed to stand it rapidly loses its usual alkaline reaction and becomes acid in character and in reaction upon litmus; concomitant with this loss of alkalinity is its loss of germicidal power, indeed such blood under these conditions is not only devoid of all germicidal power but even affords an excellent culture medium. So also, altered and morbid discharges form good culture media in which micro-organisms develop and flourish because they find ample pabulum therein. To prevent the occurrence of this condition we must either prevent discharge from the wound or else if such occurs prevent its subsequent infection. This may frequently be done by means of absorbent drying powders which inspissate such discharges and keep the wound dry and

hence nearly aseptic. The presence of an antiseptic or inhibitory agent in such dressings will prevent the development of micro-organisms altogether. If hypersecretion results, infection is almost certain to occur unless the discharges be thoroughly and efficiently sterilized and antiseptized. The functions of an ideal dressing are two-fold (*a*) to inspissate moderate discharges by absorption and subsequent evaporation of the liquid portion of such discharge and thus present a dry field in which micro-organic development is inhibited, or (*b*) when such discharge becomes profuse to prevent infection by charging such secretions with antiseptics, or if infection has supervened to effect sterilization by the same agency. Many dry dressings possess only the first quality, the best possess the second as well—among these we might mention salol, naphthol, Sennine, and to a certain extent, iodoform. These, with the possible exception of Sennine, have a comparatively low solubility in the wound discharges and hence possess very limited powers of penetration of wound recesses. Sennine by virtue of its greater solubility has powers which are more marked in this respect and hence it may be classed among the very best of all dry dressings for all purposes. The known hygroscopic properties of carbolic acid give this product of carbolic and boracic acid the inspissating power which is so desirable in a dry dressing; being a powder its power of absorption is increased mechanically to some extent by virtue of a modified form of capillary attraction. To this is added the marked antiseptic, bland and non-irritating properties

of boric acid and the marked germicidal power of carbolic acid which has been almost entirely robbed, by the combination, of its usual irritating qualities. Hence in this substance we have the two-fold function of an ideal antiseptic dry dressing fulfilled in a manner almost ideal in itself. These facts are fully borne out by a comparatively extended clinical experience, in addition to the strong scientific foundation upon which they are reared.

The present is distinctively an age of dry dressings and from the present outlook the future is to be more so, if not, indeed, exclusively an age of dry dressings. In order to gather definite information upon this point the writer has for the past six months or more been in communication with the leading surgeons of the world; from this correspondence he has gleaned a symposium of their respective opinions upon the value of dry dressings in general. In each case the surgeon expressed the opinion knowing that it was to be used as his own expression upon the subject, for so he was informed.

Thomas Annandale, Regius Professor of Clinical Surgery, University of Edinburgh: "I prefer dry dressings in all cases except where owing to large cavities and other conditions drainage is required."

Thomas Bryant, London, England: "I always use dry absorbent dressings for fresh wounds. * * * I finally dust the wound before closing it, with a powder composed of one part of iodol and four parts of powdered boracic acid."

Victor Horsley, London, England: "I use dry dress-

ings wherever possible and avoid hemorrhage as much as possible."

W. W. Keen, Professor of the Principles of Surgery and Clinical Surgery, Jefferson Medical College, Philadelphia; Surgeon to Saint Agnes' Hospital, Philadelphia, Pa.: "I almost always use dry dressings, antiseptic or sterilized, rarely wet."

Nicholas Senn, Professor of the Principles of Surgery and Clinical Surgery, Rush Medical College, Chicago; Surgeon-General, Illinois National Guard; Surgeon-in-Chief, Saint Joseph's Hospital, Chicago; Attending Surgeon, Presbyterian Hospital, Chicago, Ill.: "I prefer dry dressings in all operations for aseptic conditions; in all other cases I rely on solutions of carbolic acid or sublimate. In operations for open tubercular lesions I give iodine solution the preference."

Roswell Park, Professor of Surgery to the Medical Department of the University of Buffalo; Surgeon to the Buffalo General Hospital; Consulting Surgeon to the Fitch Accident Hospital: "I would say that more and more as the months go by I am in favor of dry operating and dry surgical dressings, and esteem that operation to be the nearest approach to the ideal in which there is the least possible amount of fluid of any kind present, either blood or antiseptic solution. In fact I do not even use hydrogen peroxide now as I used it once."

William Hunt, Surgeon to the Pennsylvania Hospital, Philadelphia: "I have been an earnest advocate of dry dressings almost since I entered the profession. One

of my earliest papers was in advocacy of them. I have never had any occasion to recede from such recommendations. Thanking you for the opportunity of answering queries like yours, I am very truly yours," etc.

C. H. Mastin, Mobile, Alabama: "I use dry dressings in small wounds and in fact in *all wounds* where I can get exact coaptation. Here I use indifferently Bismuth, Aristol and sometimes Iodoform, but its odor is objectionable, and I do not think it possesses any advantage over Aristol, Europhen or Boric Acid. I might add I use more Boracic Acid for small wounds, than anything else. Where I am unable to get *exact* coaptation, I am forced sometimes to use moist dressings. As a rule I prefer *dry* dressing, first covering with the selected articles (Boric Acid, Bismuth, Aristol or such articles as I prefer at the time), then several folds of gauze, (Iodoform, Mercuric, Boric, Eucalyptus or simple dry gauze) cotton, gauze and then bandage."

D. W. Yandell, Professor of the Principles of Surgery and Clinical Surgery to the Medical Department of the University of Louisville, Kentucky: "I like dry surgical dressings where I can use them on perfectly dry surfaces which I can keep dry by complete drainage."

Theo. A. McGraw, Professor of Surgery to the Detroit Medical College; Surgeon to Saint Mary's Hospital; Surgeon to the Harper Hospital, Detroit, Michigan: "I aim to keep my wounds aseptic and am fond of the dry method of operating."

Augustus C. Bernays, St. Louis Missouri: "I consider that the dry treatment of wounds is the ideal

method in all cases where an aseptic operation can be performed, where there is no sepsis before the operation and where there is no infection during the operation.

"Recently an excellent powder for the dry treatment of wounds has been put before the profession in a most convenient form under the name of 'Sennine.'"

Frederic H. Gerrish, Surgical Instructor to the Portland School of Medicine; Professor of Anatomy to the Medical Department of Bowdoin College: "I use carbolic solution for the instruments and sublimate solutions for hands and the field of operation, first scrubbing these with hot water and soap Dry iodoform on the wound, and above this a voluminous dressing of sublimate gauze have served me so well for so many years that I feel little disposition to abandon them for any new things which I have yet seen."

E. H. Bradford, Instructor in Clinical Surgery to Harvard Medical School; Visiting Surgeon to the Boston City, Children's and Samaritan Hospitals: "I prefer dry dressings in aseptic surgery in all cases where the wound is aseptic."

George Wiley Broome, Professor of Surgery and Dean of the Woman's Medical College, St. Louis; Surgeon to the Woman's Hospital, St. Louis. In a recent letter to the writer Doctor Broome said:

"Any physician may see and appreciate the great valne of dry dressings in surgical cases. I may go a little further and venture the prediction that the scientific surgery of the near future will not even include the now widely used irrigating vessels in the instrumen-

tarium of the surgeon at all. Instead of irrigations the asepticity of a wound will be secured and maintained by dry sponging. In suppurating cases asepsis will be established by destroying the medium in which the pyogenic micro-organisms grow and multiply, by the same means. The availability of any antiseptic is enhanced in proportion to the degree of its inhibitory power. The inhibitory function can be performed perfectly in a dessicated field only. Dessication can only be secured by means of dry, together with hygroscopic dressings. A suppurative inflammation with the presence of pus, wherever found in the human body, must be treated by dry sponging, not by irrigation, so that it will only be a little while until the application of powders possessing such power will be a universal practice among progressive surgeons.

"Latterly I have been using 'Sennine' to dust over laparotomy wounds *and have found it superior in many essential particulars to other antiseptic powders.*"

In a recent paper entitled "Some Fresh Points in the Technique of Celiotomy, Extra Peritoneal Abdominal Hysterectomy and Ideal Myomectomy," read before the St. Louis Medical Society and published, April 7, 1894, in the WEEKLY MEDICAL REVIEW of St. Louis, he says further:

"I am strongly partial to dry dressing and dry sponging. I believe that one of the greatest achievements of scientific surgery belongs to the future in this particular direction. When practical surgeons become more familiar with the life, habits, growth and development

of the pyogenic microbes, then they will learn to appreciate more fully the importance of an early and absolute abandonment of the practice of irrigation and I furthermore wish to make this declaration now: that ideal surgery can, in the near future, contemplate the act of the irrigation of wounds and cavities only in the light of a revolt against the science of regeneration. I mean this statement for a sweeping one covering all cases, and especially pus cases, those very ones that are looked upon to-day as presenting the ideal condition for irrigation, dry sponging is the fresh point therefore that I wish to show, whether it be for a pyocelia or a suppurative otitis media, I care not which. Dry sponging and dry dressing will be the practice of the future. Dry sponging is more rational in every respect than the irrigating method or wet sponging. Dry dressings by means of powders have proven more satisfactory because of their inhibitory power.

"The relative value of these powders is a subject I do not care to discuss further than to mention the very great value of iodoform in all tubercular processes and boracic acid and phenol in combination as an ideal antiseptic and dessicant.

"You know that iodoform was first introduced to the profession by Mosetig Moorhof in the year 1880 and is composed of alcohol, iodine, carbonate of potash and water and its real merit, as an inhibitory agent depends upon its slow decomposition and the liberation of iodine. The latter acting in two different ways. The one is the antiseptic property of iodine destroying germ life, the

other is the chemical property of iodine to eliminate the toxines rendering them insoluble and therefore unabsorbable and thus innocuous to the system. The hygroscopicity of the impalpable powder of boracic acid is too widely known to require explanation, and since the father of antiseptic surgery still clings to the use of carbolic acid I need scarcely consume your time in commending the inestimable value of a combination in powder form of boracic acid and phenol. These have been happily incorporated under the name of 'Sennine' and I know of nothing superior as a topical dressing to prevent parasitism and thus secure the early and rapid healing of a surgical wound."

In order to obtain the very latest and most reliable views upon these subjects, the author has been in constant correspondence with many eminent medical gentlemen for some time. The correspondence has been peculiarly valuable, instructive and edifying—indeed, it is a source of very great regret that space does not permit the publication of the correspondence in full. The author is deeply indebted for the uniform courtesy and patience with which he has been indulged by these professional gentlemen, the demands upon whose valuable time must have been multifarious. In almost every single instance there has been a marked display of that true scientific brotherhood in which each lends his aid freely and willingly to a brother investigator—indeed, the correspondence has brought out in a remarkable degree that indissoluble tie of brotherhood and unity which binds the medical gentlemen of all ages, races d climes.

Professor Doctor Vincent Czerny, Professor of Surgery to the University of Heidelberg:—"I use, almost exclusively, gauze and wadding that has been sterilized with streaming steam. Both are first boiled in a 0.6 per cent. salt solution and then sterilized in steam. The catgut is sterilized in 1 per cent. bichloride solution. For disinfection of the hands we use Fuerbringer's method. For disinfection of wounds we use the following: Iodoform gauze and cloth which has been sterilized and dipped in 10 per cent. iodoform-ether solution. For moist bandages we generally use 1 per cent. of aluminic acetate."

Professor Doctor Carl Gussenbauer, Professor of Surgery to the University of Prague: — "In answer to your question I would say that the aseptic and antiseptic methods are in use in my clinic. Asepsis is secured by sterilization of the instruments and of the materials used for bandaging. For antiseptic purposes I use the corrosive bichloride of mercury (1:1000), and for the intestine salicylic or boracic acid. For dry bandages and for the tamponade of wounds which have been infected, and also in cases of tuberculous accumulations, I use iodoform. For moist bandages, when treating cases of acute purulent inflammation, I use the acetate of aluminum. For ligatures I use catgut, and for stitching, carbolized silk thread.

"We have recently made some other experiments with different antiseptics, but have found nothing more satisfactory than those mentioned. I hope that these few brief indications will be of service to you."

Professor Doctor Friederich von Esmarch, Professor of Surgery to the University of Kiel:—In answer to my letter, Professor Esmarch, who is without doubt the greatest military surgeon of the world, sent me a copy of his *Handbuch der Kriegschirutgischen Technik.* This work was offered in competition for the large prize to be awarded by the German Empress for the best work on the technique of military surgery. A jury consisting of Professor Doctor B. von Langenbeck, of Berlin; Professor Doctor Billroth, of Vienna, and Professor Doctor Socin, of Basle, awarded the prize to this work of Esmarch. It is undoubtedly one of the greatest, if not the greatest, work on military surgery in any language. In it Esmarch describes and prescribes in detail various preparations of phenol, sublimate, zinc chlorid, boric acid, aluminic acetate, salicylic acid, chromic acid, thymol, potassic permanganate, benzoic acid, iodic tri-chlorid, tri chlor phenol, chlorin, alum, aseptin, sulphates of zinc and copper, zinc sulpho carbolate, aseptol, eucalyptol, oil of juniper, hydrogen peroxid, absolute alcohol, iodoform, bismuth subnitrate, naphthalin, zinc oxid, sozo iodol, dermatol, aristol, di-iodo-thio-resorcin, sulph aminol, salol, etc , as antiseptics in the form of solutions or as dry dusting powders.

Doctor Thomas Annandale, Regius Professor of Clinical Surgery to the University of Edinburgh:—"*First*—In all cases of aseptic wounds, operative or otherwise, carbolic solution (1:40) is used and the surface of the wound well douched with it. Before closing the wound all fluids are pressed out, and then a

piece of muslin which has been kept in a carbolic solution (1:40) is applied next the wound, having the fabric previously well-squeezed so as to leave it just damp. Over this one or more layers of wood wool or corrosive wool, according to the probable amount of serous or other discharge, are applied and all are kept in position by a soft *flannel* bandage.

The dressing is not interfered with until—

a. Any discharge shows through the dressing.

b. Any rise in temperature.

c. Irritation or swelling felt by the patient in the part.

Second—Septic wounds are treated by thorough washing with carbolic solution (1:20); by the free use of iodoform; by the application of charcoal poultices, in which I have great faith; and, in the case of the limbs, the antiseptic bath is used when possible."

Doctor John Chiene, Professor of Surgery to the University of Edinburgh:—"Thorough preparation of the skin of the patient, surgeon and assistants with soap, water, turpentine and methylated spirits, followed by 1:20 carbolic acid. Instruments boiled and then laid in 1:20 carbolic acid. Dry corrosive sublimate dressings; swabs, not sponges, of gauze, or wool enclosed in gauze (as shown me by Mr. Cotterill, Assistant Surgeon, Edinburgh Royal Infirmary); rarely use drainage tubes, careful pressure taking the place of drainage, taking great care to arrest haemorrhage at the time of the operation."

Dr. Thomas Bryant, London, England: "I always

use dry dressings for fresh wounds and of these I prefer the wood wool tissue, that is wood wool mercuriated and enclosed between two layers of gauze.

"I employ warm or hot water stained of a cherry color with the tincture of iodine to saturate the sponges I use in operations; and always apply to the surface of a wound, before its dressings are applied, a sponge wrung out in very hot iodine water to stop capillary oozing. I finally dust the wound before closing it, with a powder composed of one part iodol and four parts powdered boracic acid.

"I usually suture my wounds with fine chromicized catgut or silk rendered aseptic by boiling in carbolic water and preserved on a metal winder in pure alcohol.

"Iodoform gauze I apply to the surface of the wound beneath the wood wool tissue. I, in all deep wounds, introduce a drainage tube of rubber for one or two days and rarely dress wounds for the first three days, if there are no indications for interference.

"In large wounds I use a simple strip of plaster applied between the sutures to keep the edges in apposition. Most of my wounds heal by 'quick union.'"

Dr. Victor Horsley, London, England: "I use sterilized water. Five per cent carbolic solution for my instruments after sterilization by boiling. For disinfection of the hands 1:500 perchloride of mercury. In cases of any doubt I irrigate with weak solutions of mercury, 1:1000 to 1:4000.

"I use dry dressings wherever possible and avoid hemorrhage as much as possible."

Dr. Reginald Harrison, Surgeon to Saint Peter's Hospital; Hunterian Professor of Pathology and Surgery, Royal College of Surgeons; London England: "Amongst the uses of antiseptics must he included their applications to operations involving the urinary apparatus. Recent researches, hased upon hacteriological observations, show that the urine is capable of heing acted upon in the course of its excretion as to render the occurrence of rigors and fevers following lesions and abrasions of the urethra, as after internal urethrotomy, divulsion, or the use of catheters and bougies, either rare or innocuous. This process is usually referred to as sterilization of the urine and was first put into prominence hy Dr. E. R. Palmer of Louisville, Ky., chiefly with the use of boracic acid administered internally as a preliminary to the operation of internal urethrotomy. For this purpose, as well as for other operations of a like nature, for two or three days previously I usually administer from five to ten grains of horacic acid in water every four hours. My results in thus preventing rigors and fever correspond with those of Dr. Palmer. This action of horacic acid is prohahly due to its being eliminated largely by the urine and there acting as a protective against bacterial development and propagation. Quinine, salol and hyposulphite of soda act much in the same way. In uncomplicated cases of purulent cystitis the last-mentioned chemical in half-drachm doses administered three or four times a day in water will often speedily clear the urine of pus and all traces of bacteria. Copaiba, sandal wood, sali-

cylic acid and cubebs have a similar, though probably feebler action on the urine as antiseptics. Amongst local antiseptics, solutions of quinine and perchloride of mercury are amongst the best for washing out the bladder. The former may be used in the proportion of two grains to the ounce of water and the latter not stronger than 1:6000. Carbolic acid as an injection for washing out the bladder often causes intense irritation when used in sufficient strength to act as a bactericide.

"These are the drugs I usually employ as antiseptics in lesions and purulent conditions involving the urinary tract."

Dr. W. W. Keen, Professor of the Principles of Surgery and of Clinical Surgery to the Jefferson Medical College of Philadelphia; Surgeon to Saint Agnes' Hospital, Philadelphia, Pa: "I have no especial antiseptic formulæ or I would gladly give them. I employ commonly carbolic acid and bichloride solutions. I almost always use dry surgical dressings, antiseptic or sterilized, rarely wet. I have practically abandoned marine sponges and use sponges made of dry bichloride or sterilized gauze rolled into balls about the ordinary size."

Dr. Nicholas Senn, Professor of the Principles of Surgery and of Clinical Surgery to the Rush Medical College of Chicago; Surgeon-in-chief to Saint Joseph's Hospital of Chicago; Attending Surgeon to the Presbyterian Hospital, Chicago, Ill.: "I prefer dry dressings in all operations for aseptic conditions. In all other cases I rely on solutions of carbolic acid or sublimate. In operations for open tubercular lesions I give iodine solution the preference."

Dr. Arpad J. Gerster, Professor of Surgery to the New York Polyclinic; Surgeon to the German Hospital, New York City; Surgeon to Mount Sinai Hospital, New York City: "I bave no favorite antiseptic formulæ. The ones I use you will find mentioned in the last edition of my book on the same subject and in a pamphlet mailed to your address to day which contains also an exposition of the principles governing the use of dry and moist dressings."

Dr. Gerster has been so freely quoted in the preceding pages and his work is so well-known that his opinions may be easily inferred.

Dr J. William White, Professor of Clinical Surgery to the University of Pennsylvania, Philadelphia, Pa.:

"My dressings are as follows:

"Skin cleansed with

"(*a*) Soap and water.

"(*b*) Alcohol.

"(*c*) Carbolic acid 1:40.

"(*d*) Sublimate 1:1000.

"Sponges are placed in a solution of 1:50 carbolic acid in 1:2000 sublimate. As little sponging or irrigation as possible, except in cases where operative area is always infected. Then a douche of 1:20 carbolic acid in 1:1000 sublimate. Drainage tubes usually dispensed with in clean wounds.

"Permanent dressings of two varieties:

"1. (*a*) Iodoform dusted thickly over edge of wound and over skin for some distance.

"(*b*) Moist crumpled iodoform gauze.

"(*c*) Moist crumpled sublimate gauze.

"(*d*) Sublimate gauze bandages.

"2. Double cyanide dressing as recommended by Lister with his latest modifications.

"Results about equally good with these two methods.

"In most general clinical work and in the majority of all operative work a mild but thorough antisepsis with a minimum of sponging, irrigation, etc., is to be preferred."

Dr. John Ashhurst Jr., Professor of Surgery and of Clinical Surgery to the University of Pennsylvania; Surgeon to the Pennsylvania Hospital; Surgeon to the Children's Hospital of Philadelphia, Pa.: "I beg to say that an account of the antiseptic measures which I employ may be found in the sixth edition of my 'Principles and Practice of Surgery' recently published by Messrs. Lea Brothers and Co., of this city."

Dr. Ashhurst therein recommends "antiseptics *diluted with good common sense.*"

Dr. J. M. Barton, Surgeon to the Jefferson Medical College Hospital; Surgeon to the Philadelphia Hospital: "I am in the habit of using at my clinics at the Jefferson College Hospital and the Philadelphia Hospital, where I have experienced assistants, aseptic measures in most of my operations, first sterilizing the parts, the sponges and the hands of the operator and assistants with some of the well known antiseptics, usually bichloride of mercury (1:1000), and preparing the instruments by boiling.

"During the operation boiled water alone is used, and

the wound is dressed with dry gauze sterilized by heat. When we cannot expect to remove the blood-stained gauze at the end of twenty-four hours, as when an open wound is packed with it, iodoform gauze is used.

"In out-of-town operations, where I cannot have my usual assistants, I rarely attempt aseptic work, but before, during and particularly after an operation, I use a strong solution of bichloride of mercury freely to the wound. The instruments and the towels surrounding the seat of operation are sterilized with a 5 per cent. solution of carbolic acid.

"I have put up in dozens, bottles each containing one ounce and a half of carbolic acid and one ounce of alcohol. One of these I carry with me to each of my private operations and empty into a quart of warm water, making a 5 per cent. solution, in which the instruments lie, in their tray, until the patient is under ether. Towels are then wetted in the solution, which removes it from the instruments, and the towels are used to surround the site of the operation and to cover the instrument table.

"The addition of the alcohol causes the carbolic acid to fully and quickly dissolve in the water.

"Dry dressings, sterilized by heat, are carried with me and applied while the parts around the wound are still wet with the mercurial solution.

"When the wound is open and infected, I use wet dressings, usually gauze wet with the mercurial solution, being careful to fully cover the dressing with macintosh to prevent evaporation strengthening the solution and causing blistering."

Dr. William Hunt, Surgeon to the Pennsylvania Hospital, Philadelphia, Pa.: "I have no favorite formulæ for antiseptic procedures; varying strengths of corrosive chlorides, carbolic acid and *hot water* meet all the requirements according to my experience."

Dr. Roswell Park, Professor of Surgery to the Medical Department of the University of Buffalo; Surgeon to the Buffalo General Hospital; Consulting Surgeon to the Fitch Accident Hospital, Buffalo, N. Y.: "My favorite application to the parts to be operated on, and which I have applied for at least twenty-four hours previously, when opportunity permits, is of green soap with 5 per cent. of lysol or of hydronapthol, perhaps a little glycerin being added to the whole mass. This I have applied on compresses, with rubber tissue outside to prevent evaporation.

"In my portable operating outfit, which I carry to all country operations, I take a saturated alcoholic solution of hydronaphthol for use upon instruments, ligatures, etc, to be used during the operation. These I place in boiling water and add to it a little of the alcoholic solution. The hot water takes up so much of it as it can, making thereby a saturated watery solution, and the rest is simply wasted, the loss, however, being insignificant.

"I am now using for almost all cases, as a means of sterilizing the operator's and assistants' hands, ordinary flour of mustard, * * * the process being about as follows:

"With a nail brush the hands are thoroughly scrubbed with green soap, then it is rinsed off. A teaspoonful

or so of the flour of mustard is then put on the hands with a little water and thoroughly rubbed into all creases and parts about the finger nails, and thus manipulated for three or four minutes. The result is the most perfect sterilization of the hands, with the least immediate after-disturbance of the skin that can possibly be produced by any means known to me. You will remember that the oil of mustard is one of the most powerful antiseptics known; in fact, all of the aromatic oils share this property with it. Quite recently I have seen cinnamon recommended in the same way, and I have no doubt that powdered cinnamon would be as good as mustard, but not so easily procured. One advantage of the latter is that it is at hand in almost every household. It is more than an ordinary antiseptic. * * * Mustard can always be recommended as a deodorizing agent when the hands have become contaminated with any foul-smelling material. For my own part, I shall have no fear in going at once from the dead room to the operating table, providing my clothing carried nothing, if I could resort to this means of disinfection and sterilization.

"It is, in my estimation, extremely desirable to have a good combined styptic and antiseptic. For this purpose I most highly recommend to you a 5 per cent. solution of antipyrin. This I have used for several years, after having first carefully tested it as an antiseptic. In solution of this strength it is a fairly powerful germicide, and if once carefully prepared with sterilized water, and kept protected from ordinary atmospheric contamination, can be used with impunity so far as danger of infection is concerned. As a styptic it is more powerful than any medicinal substance with which I am familiar. I have used it on and in the brain, on and in the abdominal viscera, have injected it into the bladder, have used it in the nose, in fact, in any and every place where oozing has given me any trouble, and have

learned to have a firm faith in its valuable properties. In my clinic I have always at hand a spray bottle from which it can be sprayed upon any oozing surface, and it is used almost daily. To many others, at home and abroad, I have demonstrated its properties in this direction, and have never known it to give anything but satisfaction."

Dr. C. H. Mastin, Mobile, Alabama: "As to antiseptic formulæ, I rarely, if ever, confine myself to any one special formula. Sometimes I use mercuric bichloride, sometimes hot water, and now and then Thiersch's boro-salicylic lotion; this last I prefer in abdominal sections. When I use mercuric bichloride, I use it as the case may be from 1,000 to 12,000 strength.

"I never use 'protective' unless in those cases where I resort to a moist dressing, and then I use oiled silk, waxed paper, or thin rubber. I do not see any special advantage of Lister's mackintosh over any one of the substitutes I have mentioned. Before all operations I have the skin clean, using green soap with brush to scour it thoroughly, then mercuric bichloric, 1:1000, 1:2000 or 1:5000, as the case may seem to require; then wash it off with boiled water and alcohol or ether. *I attempt to clean the parts.* In other words, I render them as near aseptic as possible, and rely more on this than the antiseptic lotions, chemicals, etc., which are so extensively used."

Dr. Theo. A. McGraw, Professor of Surgery to the Detroit Medical College; Surgeon to St. Mary's Hospital; Surgeon to the Harper Hospital, Detroit, Mich: "I have little faith in antiseptics *except for prophylactic purposes.* I aim to keep my wounds aseptic, and am fond of the dry method of operating. Usually before operating, I have the skin shaved with soap and water, then with ether, and finally with a 2 per mille solution of corrosive sublimate."

Dr. Frederick H. Gerrish, Surgical Instructor to the

Portland School of Medicine; Professor of Anatomy to the Medical Department of Bowdoin College: "I use carbolic solution for the instruments, and sublimate solution for the hands and the field of operation, first scrubbing them with hot water and soap. Dry iodoform on the wound, and above this a voluminous dressing of sublimate gauze have served me so well for so many years that I feel little disposition to abandon them. Results have been so satisfactory with this treatment that I shall continue to follow the plan until there appears more reason than at present for a change."

Dr. D. W. Yandell, Professor of the Principles of Surgery and of Clinical Surgery to the Medical Department of the University of Louisville, Ky.: "The three antiseptics that I use in my practice are corrosive sublimate, iodoform and carbolic acid. The first and last I use in varying degrees of strength; the second usually in powder or on gauze. I do *not* use corrosive sublimate in abdominal sections."

Dr. E. H. Bradford, Instructor in Clinical Surgery to the Harvard Medical School; Visiting Surgeon to the Boston City, the Children's and the Samaritan Hospitals, Boston, Mass.: "I can only say that I make use of very simple antiseptics. Corrosive sublimate (1:1000—1:3000), iodoform in powder, aristol in powder, and peroxide of hydrogen of various strengths. Carbolic acid is used, of course, and for ointments, aristol and vaseline."

Dr. J. McFadden Gaston, Professor of Surgery to the Southern Medical College, Atlanta, Ga.: "In septic conditions, my reliance has been chiefly upon the following, giving preference in accordance to the case in the order named:—

"Labarraque's solution, with the addition of permanganate of potash.

"Lugol's solution, diluted with varying quantities of boiled water.

Carbolic acid, one ounce; glycerine, three ounces and boiled water, one pint (more or less, to suit the case).

"Spirits of turpentine, one ounce; camphor, one drachm, for first applications and afterwards, with addition of like quantity of olive oil.

"Peroxide of hydrogen is often employed as preparatory to other measures.

"My use of corrosive sublimate is limited to cleansing the skin in the field of operations."

Dr. Henry R. Wharton, Demonstrator of Surgery to the University of Pennsylvania, Philadelphia, Pa.: "I fear I have no special antiseptic formulæ. I use bichloride solution (1:2000 or 1:4000) and, in special cases, boiled water for the irrigation of wounds. I use largely, in antiseptic dressings, the modified moist method; that is, applying next to the wound a few layers of gauze, wrung out in bichloride solution, over this a pad of dry bichloride gauze, and over this a pad of bichloride cotton and a bandage. I also frequently use dry sterilized gauze, and think my results with it are equally good."

Dr. J. E. Michael, Surgeon to the University Hospital; Consulting Surgeon to the Presbyterian Eye, Ear and Throat Hospital, Baltimore, Md.:—"My method is to have the surface of the field of operation thoroughly cleansed with soap and water, then treated with ether or alcohol and recleansed, after which I have the part covered with a moist dressing of 1:1000 or 1:2000 bichloride solution for several hours prior to operation. I do not believe there is any necessity for applying an antiseptic solution to fresh tissues during an operation, but place my main reliance upon cleanliness and thorough disinfection of the seat of operation, as well as of hands, instruments and all other matter likely to come in contact with the wound.

"My dressings are mainly simple sterilized gauze or iodoform gauze. In obstetric practice, save in the pre-

ventive preparation of the external parts involved, upon the lines laid down above, I make no use of antiseptics in normal cases. In instrumental and manipulative cases I depend upon douches of sublimate solution of the strength of 1:1000 to 1:10000, depending upon the parts involved."

Dr. George Wiley Broome, Dean of the Woman's Medical College; Professor of Surgery to the Woman's Medical College; Surgeon to the Woman's Hospital, St. Louis, Mo. (See his remarks quoted under the discussion of "Dry Pulverulent Dressings").

Dr. A. C. Bernays, Professor of Anatomy, Woman's Medical College, St. Louis, Mo.: "The following are some of my favorite formulæ:

℞ Collodii, - - - - fl℥iv.
Hydrargyri bichloridi, - - gr.j.
M.
S. To be used with a brush over stitches and incision so as to seal wound.

℞ Acidi Borici.
Bismuthi subnitrici, aa ℥ij.
M.
S. To be dusted on the incision very profusely so as to cover up the stitches.

"Recently an excellent powder for the dry treatment of wounds has been put before the profession in a most convenient form under the name of Sennine."

The author himself will add that he has secured with the dry dressing which Dr. Bernays mentions (Sennine, a combination of phenol and boric acid) most exceptional results in cases amenable to dry treatment—indeed, in one case of accidental incised wound of the hand in which he was himself his own patient, the process of repair was naught less than an ideal one. These results, as we have previously noted, have been corroborated by a large number of eminent medical gentlemen.

We may summarize some of these statements and researches as follows, bearing in mind that this is by no means complete otherwise:

CARBOLIC ACID.—Gussenbauer, Esmarch, Lister, Annandale, Senn, Barton, White, Chiene, Horsley, Gerrish, Gaston, Hunt, Keen, Yandell, Bischoff, Bar, Fritsch, Winckel, Lucas Championniere, Kocher, Gerster, etc. *Used exclusively by:* Lister, Chiene, Annan dale, Horsley. Bischoff, Fritsch, Winckel, Lucas-Championniere, and others.

CORROSIVE SUBLIMATE.—Czerny, Gussenbauer, Esmarch, Keen, Barton, Hunt, White, Bernays, Michael, Wharton, Bradford, Gerrish, Gaston (only for the purpose of cleansing the skin in the vicinity of operation), Senn, McGraw, Yandell, Harrison, Gerster, Mastin, Kocher, etc. *Used exclusixely by:* McGraw, Michael and Wharton.

IODOFORM.—Esmarch, Czerny, Gussenbauer, Michael, Bradford, Gerrish, Yandell, Barton, White, Mastin, Gerster, Kocher, etc.

SENNINE —Broome, Yarnall, Bernays, Heine Marks, Mastin, Martin, Morse, Buchanan, etc.

BORACIC ACID.—Harrison, Mastin, Bernays, Kocher, Buchanan, etc.

IODIN.—Senn, Bryant, Gaston, etc.

BISMUTH SUBNITRATE.—Esmarch, Kocher, Bernays, Mastin, etc.

HYDRONAPHTHOL.—Park, Flower, etc.

SALOL —Esmarch, Harrison, etc.

HYDROGEN PEROXID —Bradford, Gaston, etc.

ARISTOL —Bradford, Mastin, etc.

IODOL.—Esmarch, Bryant, etc.

MUSTARD.—Park.

ANTIPYRIN.—Park, etc. (Used as an antiseptic styptic.)

DOUBLE CYANID OF ZINC AND MERCURY.—White, etc.

AUTHORS.

Abbot, 95, 140, 152, 184, 211, 212
Adet de Roseville, 29.
Agrigentum, 11.
Allen, 119.
American Public Health Association, 210.
Anel, 24.
Annandale, 285, 322, 330.
Anthoine, 150.
Arcaeus, 17.
Aristotle, 18.
Arloing, 118, 122, 179, 203.
Arnold, 259.
Ashhurst, 336.

Bantock, 238.
Barton, 336.
Baumgarten, 43, 63.
Bataille, 97.
Bayard, 27, 120.
Baxter, 122, 123.
Beauperthius, 29.
Beck, 170.
Behring, 67, 70, 71, 75, 76, 146 150, 157, 158, 198, 216, 295.
Bell, 26, 27.
Bellosti Augustin, 23.
Bergmann, 31, 54, 310, 311, 314.
Berkley, 28.
Berlioz, 206.
Bernays, 191, 318, 324, 344.
Besclin, 149.
Beu, 199.
Bilgner, 24, 27.
Billroth, 244, 279, 330.
Binz, 25.
Bitter, 70.
Blanc, 206.
Blondus, Michel, 14.
Blount, 98.
Blunt, 91.
Blythe, 122.
Bochefontaine, 25.
Boer, 100.
Bolton, 121, 123.
Booerhave, 24.
Bourget, 182.
Boyle, Robett, 20.
Bradford, 325, 342.
Braun, 271.
Braunschweig, 59.
Brieger, 51, 56, 80, 104.
Brignot, 244.
Brodnax, 199.
Broome, 196, 197, 318, 325, 326 344.

Browning, 315.
Brugnatelli, 56.
Bruno, 13.
Bryant, 322, 331.
Buchholtz, 108, 109, 113.
Budd, 33.
Buechner, 53, 59, 60, 63, 67, 70 72, 76, 158.

Cadcac, 87, 118, 149, 162.
Cadet de Gassicourt, 53.
Caignard de la Tour, 6, 28, 29, 32
Callender, 185.
Calvert, 32, 33, 120, 122, 123.
Cannon, 43.
Cattani, 75, 76, 79, 80, 228.
Chaumette, 27, 120.
Chautard, 156.
Cerna, 101, 103.
Cheyne, 84, 121.
Chiene, 331.
Christmann, 70, 151.
Christmas, 166, 170.
Cohn, 41.
Colasanti, 147.
Colbatch, 21, 27.
Col de Villars, 24.
Cornevin, 118, 122, 179, 203.
Cozzolini, 164.
Cunningham, Lewis and D., 66 84.
Curtmann, 100.
Czerni, 297, 329.

Dann, 53.
Darzens, 172.
Davainne, 30, 32, 122, 123.
Davidsohn, 286.
D'Egineta, 13.
Delacroix, 16, 97, 129, 211.
De la Tour, 6, 34.
Delavan, 98.
Demosthenes, 253.
Dennis, 245.
De Ruyter, 314.
De Vigo, 14.
Desnos, 181.
Disneuf, 184.
Doering, 177.
Donne, 29.
Dougall, 108, 122
Douglass, 123.
Downes, 91.
Draer, 205.
Dubois, 172.
Duclaux, 168.
Dulerly, 171.
Dujardin-Beaumetz, 30, 127.
Duggan, 117.
Dumas, 120.
Dupre, 53, 54.
Dupuy, 53.
Duroy, 157.

Eberth, 42, 229.
Emmerich, 70, 71, 75, 148.
Empedodes, 11.
Empis, 184.
Erand, 98.
Esmarch, 317, 330,
Ezechias, 12.

Faktor, 99.
Fassbender, 55.
Ferran, 154.
Feuerbringer, 262, 301, 303.
Fischer, 97, 122, 145.
Fisher, 128.
Fleck, 108.
Flint, 187.
Fodor, 66, 70.
Foote, 165.
Forster, 104.
Fortchinskey, 229.
Fowler, 247.
Fox, 214.
Fraenkel, 76, 229.
Frisch, 87.
Fritsch, 182.
Fritze, 27.

Gaillard, 91.
Gaffky, 43.
Garrigues, 269.
Gaspard, 53.
Caston, 342.
Gautier, 48.
Gay Dussac, 28, 29.
Geister, 91.
Geppert, 138.
Gerrish, 325, 341.
Gerster, 227, 248, 253, 255, 256 275, 283, 292, 295, 298, 302, 305 306, 308, 311, 316, 318, 335.
Ghriskey, 136, 176, 259, 261, 285
Globig, 88.
Goldmann, 103.
Goldschmitt, 177.
Gordon, 259.
Gottstein, 161.
Graucher, 156.
Grohmann, 66.
Grube, 108.
Guareschi, 56.
Gubler, 184.
Guiboust, 27, 120.
Gschiedlon, 66.
Guinard, 162.
Gunning, 55.
Gussenbauer, 329.
Guttman, 145, 205.
Guyton, 128.

Hallibuston, 70.
Hallier, 25.
Halsted, 127.
Hamilton, 237.
Hansen, 41, 212.
Hardenbergh, 188.
Harder, 196.
Hardesty, 196.
Hare, 121, 188.
Harris, 260.
Harrison, 333.
Haschimodo, 95.
Haukin, 56, 70, 71.
Helferich, 310.
Helmholtz, 29, 30.
Heister, 24.
Hemmer, 54.
Hennemann, 54.
Herbot, 25.
Hildebrandt, 60.
Hirne, 127.

Hitchmann, 188.
Hock, 215.
Hoffa, 56.
Horsley, 322, 332.
Hoppe-Seiler, 122.
Huenefeld, 54.
Hueppe, 107, 204, 206.
Hueter, 40.
Hugge, 122.
Hunt, 323, 338.
Hunter, 26.

International Congress of Physicians and Surgeons at Brussels, 267, 268.

Jaeger, 116, 176.
Jasuhara, 75, 76.
Jeannel, 15.
Jenner, 74.
Johnson, 113, 227.
Jones Beuce, 54.

Kaposi, 215.
Karlow, 231.
Keen, 127, 298, 323, 334.
Kelly, 136, 176, 259, 261, 262, 264 285, 303.
Kern, 27.
Kerner, 53.
King of Servia, 249.
Kingzett, 188.
Kirchner, 130.
Kitasato, 75, 76, 80, 95, 99, 113 116, 132, 152, 161, 167, 171, 173 174, 175, 184, 199, 211.
Klebbs, 42.
Klein, 96, 140.
Klemperer, 76.
Koch, 40, 41, 49, 56, 89, 90, 91, 95 96, 97, 99, 105, 108, 116, 121 122, 123, 129, 130, 133, 135, 149 153, 157, 166, 167, 173, 174, 175 184, 198, 210, 216, 218, 219, 220 229, 279.
Koch, E., 188.
Kocher, 284, 293, 296, 303, 306 308, 312, 314.
Kolbe, 183, 184.
Kopp, 151.
Kresin, 145.
Kronacher, 148.
Kuemmel, 282, 301, 302.
Kuhn, 97.

Lafage, 150.
Lanfranc, 13.
Langenbeck, 28, 330.
Langenbuch, 157.
Laplace, 122, 142, 145.
Laser, 188.
Laveran, 42.
Lazerus, 64.
LeBoeuf, 20.
Leeuwenhock, 19, 28.
Lefort, 97.
Lemaine, 33, 120.
Leuret, 53.
Leviticus, 11.
Limpricht, 183.
Lindemann, 79.
Lister, 4, 21, 27, 29, 34, 35, 36, 37

38, 39, 40, 41, 43, 112, 120, 125 126, 140, 142, 158, 163, 218, 241 278, 279, 285, 305, 306, 318.
Loeffler, 42.
Loew, 70.
Loewenthal, 186.
Lombard, 26.
Lomboso, 56.
Longard, 85.
Lucatello, 229.
Lukaschewitsch, 168.

Macknoff, 59.
Magatus, 19.
Magendie, 53.
Maison d'Accouchments, 267.
Malet, 87.
Marks, 1 6, 318.
Martin, 43, 318.
Mastin 95, 318, 324, 340.
Mater y Hospital, New York 270.
Mayer, 25.
Mayow, 27.
McClintock, 70, 77, 96, 285.
McDowell, 235.
McGraw, 324, 341.
Meigs, 26 .
Menz, 202.
Meyer, 54, 215, 229.
Merk, 100.
Mermann, 270, 271.
Meunier, 118, 149.
Michael, 343.
Mikulicz, 312.
Miquel, 88, 97, 99, 100, 105, 107 108, 109, 113, 116, 122, 127, 131 135, 147, 153, 162, 164, 167, 173 175, 176, 179, 198, 199, 203, 212 217, 218.
Morand, 52.
Morse, 195.
Morton, 245.
Moses, 11.
Mosetig von Moorhoff, 313, 327
Mosso, 56.
Mueller, 25.

Neisser, 41, 158, 217.
Nelaton, 97.
Nenki, 53, 55.
Neuber, 282.
Neudorfer 22, 143, 158.
Neuhaus, 225.
Newton, 3.
Nicati, 123.
Nicolaier, 43.
Nissen, 70, 93, 117.
Nold, 196.
Novy, 70, 77.
Nussbaum, 242, 310.
Nuttall, 66.

Oatman, 196.
Obermeyer, 41.
Ogata, 75, 76.
Ogston, 84, 184.
Ohmann-Dumesnil, 192.
Orfila, 53.
Orthenberger, 67.
Oswald 188.

Palmer, 333.
Panum, 31. 54.
Paracelsus, 15.
Parc, 15, 26, 27.
Park, 100, 177, 323, 338.
Parmanus, 24.
Parisi, 25.
Parset, 84.
Pasteur, 30, 32, 33, 34, 35, 40, 41 42, 75, 241, 299.
Paul, 90.
Patt, 25.
Pekelhomig, 70.
Pepper, 12, 44.
Perci, 26.
Personne, 127.
Perret, 150.
Pertij, 31.
Petri, 199.
Pfeiffer, 43.
Pfiuhl, 116.
Pharmaceutische Zeitung, 178.
Pippingskoeld, 270.
Playfair, 259.
Pollender, 30.
Polli, 25, 31, 201, 203.
Portes, M., 179.
Prestley, 26.
Price, 239.
Pringle, 25.
Prosskauer, 128, 129.
Prudden, 87.

Quinke, 184.

Ranke, 216.
Raschig, 143.
Rayer, 30, 32.
Reiche, 186.
Reynier, 187.
Ribbert, 59, 84.
Richter, 26.
Riedlin, 100 149, 159.
Rietch, 123.
Robb, 136, 176, 259, 261, 285.
Roberts, 177.
Robin, 31, 160.
Rogerius, 13.
Rohe, 90, 129.
Rosenbach, 122.
Rosenthal, 113.
Roth, 59.
Roux, 76, 153.
Rutter, 260.

Salkowski, 108, 130.
Salmon, 79.
Schede, 279, 312.
Schill, 97, 123, 145.
Schimmelbusch, 59, 286, 287, 289 290, 291, 320.
Schlange, 319.
Schmidt, 54, 66.
Schmiedeberg, 31, 54.
Schroeder, 31.
Schroeter, 122.
Schulze, 28, 29, 30, 34.
Schumann, 53.
Schutz, 42.
Schwan, 29, 30, 34, 39, 40, 241.
Schwartz, 228.
Schweninger, 54.

Scrivner, 196.
Seibel, 160.
Seitz, 210.
Selmi, 52, 55.
Semmelweiss, 271.
Senn, 318, 323, 334.
Sertuerner, 54.
Sevet, 120.
Shimwell, 155, 156.
Shmitt, 76.
Sivet, 27.
Sittmann, 67.
Socin, 279, 330.
Solis-Cohen, 114.
Solomon, 12.
Sonnenschein, 55.
Suergnersky, 107.
Spence, 242.
Spengler, 98, 310.
Squibb, 103, 107, 115, 124, 159, 160, 165, 178, 205, 208.
Steffen, 104.
Steinmetz, 70.
Sternberg, 42, 63, 76, 87, 88, 91, 100, 109, 112, 113, 122, 123, 127, 133, 145, 152, 155, 159, 166, 174, 175, 179, 184, 201, 209, 210, 211, 225.
Stich, 54.
Stille, 98.
Stilling, 100.
Stimson, 123, 224, 280.

Tait, 238.
Tavel, 287, 303, 305, 308.
Tassinari, 217.
Tchourilow, 115.
Theophrastus, .
Thiersch, 185, 279.
Thinot, 210.
Thomas, 118, 122, 179, 203.
Thornton, 238, 246.
Tilanus, 158.
Tizxoni, 75, 76, 79, 80, 228
Tour, 6.
Traube, 66.
Trousseau, 53.
Tsuboi, 70.
Tyndall, 91, 287.

Unna, 180.
Ure, 29, 30.

Van Ermengem, 93, 132.
Vaughan, 56, 68, 69, 70, 71, 72, 73, 77, 78, 79, 80, 84.
Velpeau, 157.
Vicary, 17.
Vicquerat, 303.
Vigo, 14.
Voelsch, 88.
Voit, 67.
Volkmann, 243, 278, 288.
Von Haller, 52.
Von Dusch, 31.
Von Kern, 27.
Von Mering, 104.
Von Walther, 27.

Wagner, 231.
Walb, 113.
Walthard, 308.

Walther, 27.
Wharton, 343.
Wassermann, 80.
Weber, 54.
Weigert, 41, 63.
Weiss, 53.
Welch, 140, 176, 285, 303.
Wells, 35
Westrumb, 54.
Weyl, 64.
White, 238, 245, 251, 335.
Williams, 196.
Wiseman, 20.
Withauer, 205.
Wolffhuegel, 89, 90
Wojtaszek, 208.
Wood, 98, 127, 185, 213.
Wooldridge, 73, 77, 80.
Wurtz, 17.
Wysokowicz, 66, 84.

Yandell, 324, 341.
Yarnall, 194.
Yersine, 88, 123, 145, 149, 171
216.

Zimmermann, 285, 305, 306.
Zirmssen, 124.
Zuelser, 55.
Zuntz, 70.

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